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Cessna Aircraft Company
Wichita, Kansas

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DESIGN AND CONSTRUCTION
PROJECT
—
MODEL 309

CONDUCTED FOR
OFFICE OF NAVAL RESEARCH
UNDER
CONTRACT NONR 234(00)

ENGINEERING REPORT
NO. 1309-1

REPORT DATE: NOVEMBER, 1951
PREPARED BY: ALLYN HEINRICH
CHECKED BY: WEB MOORE & KENNETH RAZAK
APPROVED BY: TOM SALTER

Cessna Aircraft Company
Wichita, Kansas

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SUMMARY

A Cessna Model 170A airplane was modified to receive a circulation control system in accordance with results as furnished from a research program conducted by the University of Wichita. The wing of the airplane was rebuilt from the 50% chord aft to contain an inboard suction slot and duct and connected to an outboard blowing slot and duct by means of a mixing tube which operated as a jet pump. An Airesearch gas turbine compressor was operated as a bleeder compressor to furnish air to a combustion chamber. The hot gases of combustion were ducted to a series of nozzles at the entrance to the mixing tube where the action of the high speed gases pumped air from the inboard suction slot through the outboard blowing slot.

The design problems produced by the installation of a circulation control system did not prove too severe. Wing structure was not seriously altered and did not reduce the strength characteristics or fuel capacity. The external appearance of the airplane was modified only very slightly. While the installation of the gas turbine compressor was entirely experimental no undue problems were encountered and an operating system has been achieved.

Preliminary flight tests have indicated that the system possessed considerable promise from the standpoint of minimum speed performance and increase in controllability. A total of 5 flights have been made demonstrating the airworthiness of the airplane and indicating the type of operations which will be required for a detailed flight test program.

INTRODUCTION

In January of 1951 the Cessna Aircraft Company was awarded a contract by the Office of Naval Research to design and construct a circulation control airplane following the aerodynamic results which were secured by the University of Wichita. Since January of 1949 the University of Wichita has been conducting research on the problems of low speed flight and conducted a series of detailed tests on a reflection plane model at full scale Reynold's numbers. This model was a one-half scale model of the wing of a Cessna Model 170A airplane which had been equipped with suction and blowing slots to provide boundary layer or circulation control. The purpose of the Cessna contract was

to: (1) Explore the design problems of incorporating a circulation control system in an actual flight airplane, and (2) To conduct initial flight tests to demonstrate the operating characteristics.

One of the initial goals of this project was economy. The Cessna 170A airplane was chosen for both the wind tunnel and flight program since it would require the modifications of an existing airplane rather than the design of a new aircraft. Also, the problems of installation on a small unit would be considerably less than on a large high performance airplane.

The design procedure was carried on in the Cessna Aircraft Company Engineering Department utilizing the regular personnel who ordinarily perform design work for commercial and military aircraft. The procedures and practices followed in this project differed but little from those followed by the Cessna Aircraft Company in producing other aircraft. The ease with which this system could be installed was felt to be a measure of its utility and considerable attention was paid to retaining the external and internal appearance of the aircraft as closely as possible to the commercial version. The final goal was to secure an airplane which would have the same performance and pay load as the standard commercial aircraft but to superimpose on this unit the performance at low speed as promised by the wind tunnel tests.

DESIGN AND PROCEDURE

The circulation control system as installed in the Cessna Model 170A is shown in Figure 1. (Note: This is a figure which shows the schematic installation of the BLC system) In the circulation system as proposed by the University of Wichita (Reference 1) air is drawn in through a suction slot at the juncture of a plain flap and the body of the airfoil. The entrance to the slot at the juncture of the plain flap and wing is varied in cross-section to regulate the flow quantity and maintain uniformity along the span of the suction flap. The air is drawn into the suction duct which converges into a 4-3/4 x 7 elliptical cross-section mixing tube where the pumping of the jet pump occurs. In the mixing tube the suction air mixes with the high velocity gases which are issuing from four stainless steel nozzles and is diffused into the blowing duct outboard of the mixing tube. From the blowing duct air is discharged through a slot, as shown in cross-section on figure 1, over a modified NACA type 2H slotted flap which is deflected down at 45°. From station 100 to station 139.6 the

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DESIGN AND PROCEDURE (Continued) - blowing flap is coordinated with the suction flap while from station 140.125 to station 207 the slotted flap is arranged to be moved as an aileron with differential linkage.

Table 1, which is a list of drawings which were released to the shop for the actual construction furnishes a complete picture of the individual projects which were required.

STRUCTURAL CONSIDERATIONS - All ducting for internal air flow as well as the jet pump was contained in the wing aft of the 50% chord point. The original wing structure of the Cessna Model 170A consisted of a front spar which carried the wing bending load, an .020 aluminum skin which formed a torsion box, and the rear spar which completed the torsion box and transmitted the torsion and drag loads to the fuselage. The wing bending load, carried entirely by the front spar, was the only critical load which was placed upon the wing and modification from the 50% chord aft produced no change in this critical structure. The stresses from torsion and drag loads were adequately carried by the remaining structure forward of 50%.

A new spar was located at the 50% chord point running straight from the wing root to the tip. Lightening holes were eliminated in this spar to permit it to serve as the forward wall of the blowing and suction chamber. The rib structure and skin between the rear and front spar remained essentially the same as the 170A. Some modification of structure was required to permit the fuel tank to extend further in the spanwise direction.

The rear spar, wing skin, and ribs were used wherever possible to form the air ducts to eliminate the need for auxiliary structure. In nearly every case it was possible to have duct components serve as structural members. The basic structure aft of the rear spar consisted of: an .091 magnesium skin, root rib, station 100 rib, tip rib, and the suction and blowing slot beams. Control surface loads and air loads in this area are carried forward to the rear spar by the ribs and the relatively thick skin. The skin was selected to withstand internal pressures up to one pound per square inch. This pressure has not been encountered in preliminary tests and lighter skin gauges can be used for later aircraft where more accurate determination of internal pressures can be secured.

The external wing strut was retained as on the commercial airplane.

Relocation of the rear spar from 75% to 50% chord required a modification of the fuel tanks. The standard tank was cut off

STRUCTURAL CONSIDERATIONS (Continued) - at the 50% chord point with an additional tank being placed immediately outboard from the original installation. The total fuel capacity in both panels was increased from the commercial value of 40 gallons to approximately 50 gallons for the circulation control airplane.

No proof load was run on the completed wing structure since modifications were of a secondary nature and did not affect the primary structural assembly.

AILERONS AND CONTROLS - The 25% chord ailerons extending from station 140.125 to station 207 were of the slotted flap configuration. The leading edge of the aileron as well as the leading edge of the blowing flap were circular arcs with a center at the hinge point. The hinge point was so located that the upper surface of the leading edge of the aileron remained tangent to true airfoil contour as the aileron was deflected downward.

The ailerons were formed of a two-piece .020 aluminum skin with rolled leading edge and formed trailing edge. The skin carried the torsion load with the bending load being carried by an .025 formed spar. The skins were lapped at the spar. The aileron was hinged at inboard and outboard ends with push-pull control rod attaching at the outboard end. This location of the push-pull rod was necessary to avoid passing through the blowing chamber with the surface controls.

The aileron control system within the wing consisted of two cables, just forward of the rear spar, running from the fuselage to a bellcrank at the wing tip. A push-pull rod connected from the bellcrank to the arm on the aileron.

BLOWING FLAPS - The division of the wing into a blowing flap and suction flap panels was determined on the basis of proper blowing and suction coefficients as determined by the University of Wichita. To produce the proper areas a blowing flap of the same configuration as the aileron extended from wing station 100 to wing station 139.6. This blowing flap was actuated simultaneously with the suction flap with a maximum deflection of 45°. No differential control was provided for this blowing flap section.

The blowing flap with .020 aluminum skin and ribs was hinged at the inboard and outboard ends using the same wing hinge bracket at the outboard end as the inboard end of the aileron. Construction and design details of ailerons and flap systems can be secured from drawings 12309-1, 12309-4 and 12309-5 as contained in the appendix to this report.

SUCTION FLAP - The suction flap of plain flap type was hinged at the lower surface of the airfoil contour with a piano type hinge. This flap as shown in drawing 12309-1 consisted of: an .025 skin for torsion loads with eight .020 ribs, and an .025 formed nose skin. The suction slot is closed when the flap is in zero position and open to its maximum value when the flap is deflected 45°. The leading edge of the flap and the trailing edge of the airfoil are designed to form the most effective entrance to the suction slot when the flap is deflected. The flap control system was connected to the inboard end of the suction flap with an interconnection from the suction to the blowing flap at the outboard end of the suction flap. The flap control cable from the fuselage passes over a pulley attached to the root rib and is then connected to a bellcrank which actuates the pushrod to the flap. The flap is spring loaded to return to the UP position.

INTERNAL DUCTS AND SLOTS - The airduct from the suction slot consisted of aluminum walls which converged to the entrance of the mixing tube of the jet pump. Zinc chromate sealing compound was placed in the joints between all duct walls and wing skins to prevent air leakage during operation of the circulation control system. The structure of the wing at the juncture of the flap and wing was preserved by trussing small aluminum tubes across the suction slot opening. The flow into the suction duct was regulated by a variable restriction which was determined from tests on a wooden mockup of the suction chamber. The flat plate type of restriction proved to be more efficient than an internal arrangement of guide vanes.

The walls of the suction duct terminated in a formed aluminum 4-3/4 x 7 elliptical cross-section of the jet pump. This tube 30 inches long provided the necessary length for the mixing of the high energy hot gases with the secondary air. A short diffuser at the outboard end of the mixing tube exhausted into the blowing duct which extended for the entire length of the blowing flap and aileron. Aluminum stay rods were spaced spanwise in the blowing chamber to stiffen the .091 magnesium skins against the internal bursting pressure. Both the suction and blowing ducts were decidedly over-strength as the result of the use of this thick skin and material. Weight reduction can be made by reducing this skin gauge in subsequent models.

The air was ejected from the blowing duct through a slot, which was formed with a gradual converging entrance, over

INTERNAL DUCTS AND SLOTS (Continued) - the upper surface of the blowing flap and aileron as shown in Figure 1.

The width of the blowing slot was first designed as 1.2% of the local airfoil chord. This figure as furnished by the University of Wichita was predicated upon estimated performance of the jet pump. When the jet pump performance of the jet had been more specifically determined the blowing slot width was altered to a value of a .747 percent. The tear drop which formed the lower surface of the blowing slot served as a structural beam at the trailing edge of the airfoil body. This beam was connected to the upper skin by a series of short spacers located at intervals of approximately 5-1/4 inches which governed the width of the blowing slot.

GAS TURBINE AND JET PUMP INSTALLATION

The air which was required to be circulated through the suction and blowing slots was pumped by an induction type pump utilizing hot combustion gases. This induction pump known as a hot jet pump had been developed in an experimental program conducted by the University of Wichita. The design data furnished by the University of Wichita specified a jet pump with four driving nozzles, an L/D ratio of 6, and a mixing tube area of approximately 26 square inches. The outlet of the driving nozzles was to lie in the entrance to the mixing tube with the actual nozzles designed and constructed at the University of Wichita.

Complete test data on the jet pump is available from the University of Wichita. (Reference 2)

The primary fluid for the jet pump consisted of compressed air which had been passed through a combustion chamber in which gasoline had been burned. The temperature of the products of combustion was regulated by controlling the quantity of gasoline.

The compressed air from the aircraft was furnished by an Airsearch Gas Turbine Compressor Model GTC 43/44-7. This gas turbine compressor which weighed 156 pounds was located in the rear compartment of the fuselage, occupying the space normally occupied by the rear seat. The turbine was installed with the axis of the turbine skewed at an angle of 15-1/2 degrees to the longitudinal axis of the airplane. The tailpipe extended from the turbine end of the enclosure at an angle of approximately 28 degrees to the side of the fuselage exhausting through an elliptical opening just forward of station 140. The complete turbine installation is shown in drawings 12309-7 and 12309-8.

INTERNAL DUCTS AND SLOTS (Continued) - the upper surface of the blowing flap and aileron as shown in Figure 1.

The width of the blowing slot was first designed as 1.2% of the local airfoil chord. This figure as furnished by the University of Wichita was predicated upon estimated performance of the jet pump. When the jet pump performance of the jet had been more specifically determined the blowing slot width was altered to a value of a .747 percent. The tear drop which formed the lower surface of the blowing slot served as a structural beam at the trailing edge of the airfoil body. This beam was connected to the upper skin by a series of short spacers located at intervals of approximately 5-1/4 inches which governed the width of the blowing slot.

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The tanks in the left hand wing panel were connected as a turbine fuel supply. A shut-off valve and strainer were provided in the fuel system before the fuel line was connected to the fitting on the turbine enclosure. The turbine contained its own fuel pump with an external connection for fuel pressure indications. This fuel pump pressure was utilized to furnish the fuel for the burner chamber with the fuel quantity being regulated by an orifice located in the fuel line to the burner chamber.

The Airesearch gas turbine compressor was a completely self-contained unit with the exception of fuel supply and electrical current. The electrical supply was furnished by a 24-volt battery located in the turbine compartment. Since the airplane normally operated on a 12-volt system this battery was independent of the airplane's regular electrical system.

The turbine operation was controlled from a small panel in the pilot's compartment which contained a turbine starting switch, a turbine stop switch, and signal lights for proper turbine operation and fire warning.

The compressed air from the turbine compressor unit passed through a venturi choking nozzle, which limited the maximum bleed output below the safe limit for the compressor unit, through a butterfly valve into the burner chamber. From the burner chamber two inch stainless steel tubes divided into each wing panel and carried the hot combustion gases to the four stainless steel nozzles at the entrance to the mixing tube in each panel. The fuel supply and ignition for the burner chamber were controlled from a single switch on the turbine control panel. The burner chamber was copied after a regular gas turbine burner chamber with the necessary modification to include it into the system as required. An inner perforated liner surrounded by an outer solid shell patterned after conventional gas turbine burner construction gave satisfactory performance on all flights. The burner chamber and the stainless steel tubes leading the jet pump nozzles were covered with an insulating blanket as furnished by the John Foster Company. This blanket of thin stainless steel foil effectively insulated the hot surfaces, which carried gasses up to 1600° F., from the adjoining structure and no overheating has been noted in the hot gas system to date.

A firewall was erected both behind the turbine and ahead of the turbine installation. The firewall behind the turbine consisted of a sheet of aluminum which was fastened to the bulkhead at station 108. The firewall ahead of the turbine was

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located to just clear the pilot's seat when in the completely aft position. This firewall was designed to accommodate the burner chamber and was heavily insulated with glass wool and fiberglass cloth. Turbine instruments were mounted in a panel on this firewall so that they would be visible to ground test observers. The pilot was unable to observe these instruments while in flight. A handle for controlling the butterfly valve position projected through the firewall within easy reach of the pilot so that he could adjust the bleed output of the turbine at any time in flight. Tailpipe temperature, turbine oil temperature and turbine RPM were indicated on the instrument panel and visible to the pilot at all times.

The fire extinguisher system consisted of a CO₂ bottle installed to deluge the area around the burner chamber and the turbine enclosure. This system was to be operated manually upon the indication of the fire warning signal or other visible evidence of fire.

PRELIMINARY FLIGHT TEST

The first five flights were made with the regular 170A and the GTC instrumentation only. These flights were conducted principally as shakedown flights to substantiate the airworthiness of the airplane. No unusual flight or structural characteristics were found. The airplane was considered ready for extensive flight testing with the additional requirement of further instrumentation.

Actual landing take-off distances were not measured. They will be measured, however, in later tests when the pilot is thoroughly acquainted with the flight characteristics of the airplane.

PILOT REACTIONS

All of the following comments pertain to the aircraft with full flaps, aileron drooped, and circulation control operating. When reference is made to power off or power on, this pertains to the main thrusting engine.

The following stall true indicated air speeds have been measured in flight. Power off, 41 mph; power on, 37 mph. These correspond to lift coefficients of 2.79 and 3.42, respectively. Difficulty exists in reading stall speeds at this low value and differences of 1 mph produce significant changes in lift coefficient. In this speed range, 1 mph corresponds roughly to a lift coefficient of .16.

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PILOT REACTIONS (Continued)

A flight has been conducted very close to the ground (about one foot altitude) at an indicated air speed of about 40 mph. No unusual flight tendencies were noticed although the airplane appears to be more sluggish in control response than a normal aircraft. This is not surprising since the controls on the airplane are those of the regular commercial version. Very little power was required to maintain flight under this condition (about 30%). An increase in power would have caused the airplane to climb if air speed were maintained constant.

The pilot is finding it difficult to establish high rates of sink at low air speeds. Maximum rates of sink are being encountered at indicated air speeds of about 70 mph. This verifies the tunnel data which indicated that relatively high L/D values could be secured in this configuration.

Stick force gradients are stable in both power off and power on, configurations, although somewhat less stable with power on. Control forces are light but not excessively light in view of the C. G. location at approximately 31 percent MAC. Aileron control forces are so light that they are almost completely masked by the friction in the control system.

Some evidence exists that the lateral stability may be very poor with full flaps and circulation control. This will have to be determined by detailed flight tests with particular attention paid to aileron position, rate of roll, and angle of bank.

The flow coefficients which are being secured are comparatively low and distribution along the blowing slot should be improved. Blowing velocities of about 120 mph are being secured over the aileron but poor distribution exists over the inboard blowing flap. Pumping capacity for the jet pump improves only about one-third when the burner is turned on as compared to that of using the compressed bleed air only. No effects are noticed when the burner is turned off in flight but a distinct sensation of loss of lift occurs when the turbine is shut off. This sensation of loss of lift is similar to that which occurs when raising a flap but of much shorter duration.

No take-off distances have yet been measured but the pilots reaction is that the distance is extremely short and that continued experience will permit additional improvement by proper piloting technique.

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PILOT REACTIONS (Continued)

As a summary statement, the pilot has stated that he has not encountered any conditions in flight which he would classify as dangerous. No attitudes have been encountered which cannot be relieved by ordinary control.

The above statements, in some cases, are not based upon actual data but more upon impressions and reactions.

CONCLUSIONS

The objective of this contract, which was to design and construct an airplane incorporating a circulation control system and to conduct preliminary flight tests, has been successfully attained.

1. The test airplane performed the same as the commercial counterpart (Cessna Model 170) when flown with the circulation control system not operating.
2. When flown under slow-flight conditions with the circulation control system operating, the test airplane was under complete control of the pilot and no adverse characteristics were evident. The aileron effectiveness was good through the stall and elevators were sufficiently effective to execute three-point landings. Apparently the down wash from the flaps was sufficient to counteract the increase in pitching moment obtained at the high lift values.
3. A definite reduction in take-off and landing distance was observed with the circulation control system operating.
4. A definite reduction in stalling speed and increase in climb angle with the circulation control system operating, was observed.
5. The incorporation of the circulation control system into the airplane presented no unusual design problems which could not be solved with standard airplane design practice.
6. No compromise was made with the structural integrity of the airplane in providing for this system.
7. The weight increase (15.5% of the normal gross weight) resulting from the circulation control system was considerably higher than necessary due to the research aspect of the

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CONCLUSIONS (Continued) - project. With the use of more favorable materials from a weight standpoint and an improved pumping method, a carefully designed system could be installed for approximately 5% of the normal gross weight.

8. Considerable flight testing will be required to provide specific information and to point up needed revisions to improve the system.

RECOMMENDATIONS

1. Other pumping methods should be investigated, developed, and tested to obtain a more efficient system both from a weight and air quantity standpoint.

2. Based on the information obtained from the detail flight test program, an "On Purpose" airplane should be designed, constructed and tested. This airplane would incorporate an optimum wing design for the circulation control system, an improved pumping system, and an improved circulation system for more effective circulation control.

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REFERENCES

1. Razak, Kenneth, Razak, Virgil, and Bondie, Jr., R. J. : Wind Tunnel Investigation of a Method of Boundary-Layer Control as applied to a Reflection-Plane Model at Full-Scale Reynolds Number. University of Wichita Engineering Report No. 032, Wichita, Kansas, June 1951.
2. Snyder, Mel H. and Rostrelli, L. V. : A Progress Report on Jet Pump Research Conducted at the University of Wichita. University of Wichita Engineering Report No. 049, Wichita, Kansas. August 1951.

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DRAWING LIST

Drawing No.	Title	Date Rel.	Change
12309-1	Aileron and Flap Assembly	10-15-51	D
12309-2	Hexcel Skin L.O.	INACTIVE	
12309-3	Structure Assembly - Wing	10-15-51	B
12309-4	Controls - 309 Flap System	10-15-51	A
12309-5	Controls - 309 Aileron System	6-12-51	N/C
12309-6	Compressor and Burner Ducts	10-15-51	B
12309-7	Turbine Installation	10-15-51	D
12309-8	Turbine and Burner Controls	10-15-51	A
12309-9	Shell - Outer Burner	6-12-51	N/C
12309-10	Liner Assembly - Burner	6-12-51	N/C
12309-11	Adapter - Nozzle	INACTIVE	B
12309-12	Suction Slot - Mock Up	6-12-51	N/C
12309-13	2412 Airfoil - Tip	10-15-51	A
12309-14	Jet Pump Assembly and Installation	6-12-51	N/C
12309-15	Fuel Tank Installation	6-12-51	N/C
12309-16	Fuselage Spar Installation & Cabin Reinforcement	6-19-51	N/C
12309-17	Union Assembly - Fuel Restrictor	8-1-51	N/C
12309-18	Union Assembly - Pressure Line Restriction	8-1-51	N/C
12309-19	Elbow Assembly - Pressure Line Restriction	8-1-51	N/C
12309-20	Schematic - Fuel System	10-29-51	A
12309-21	System - Burner Electrical	8-1-51	N/C
12309-22	Adapter - Blowing Slot	8-14-51	N/C
12309-23	Three View - Model 309	10-15-51	N/C
12309-24	Valve Installation - Bleed Air	10-15-51	A

REFERENCE MANUALS

Air Research Operation and Service Instructions Report 3-66	6-9-51	N/C
Air Research Model Specification Gas Turbine SC 242 Compressor	6-9-51	No. 2
Air Research Installation Manual Gas Turbine Compressor Unit	6-9-51	No. 1
Air Research Valve (installation outline) 92750 3 inch shut-off	8-31-51	
Air Research Model Specification Gas Turbine SC 242 Compressor Model GTC 43/44-5 and Model GTC 43/44-7	7-16-51	Rev. 3

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LIST OF FIGURES

- | Figure
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|--------------------------|---|
| 1. | Circulation Control System (BLC System) -
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| 3. | Jet Pump Nozzle and Duct Tube Weld Assembly |
| 4. | Bottom View Suction Chamber and Inboard End
of Mixing Tube - Without Skin |
| 5. | Top View Blowing Chamber and Outboard End
of Mixing Tube - Without Skin |
| 6. | Bottom View of Assembled Right Wing |
| 7. | Bottom View of 170A Wing |
| 8. | G.T.C (Gas Turbine Compressor), Choking Nozzle,
and Bleed Air Valve Installation |
| 9. | G.T.C. Installation |
| 10. | G.T.C. Exhaust |

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APPENDIX

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PARTIAL WEIGHT BREAKDOWN

Model 309






The following list contains the weight breakdown of the airplane into weights of major components, major installation, and empty airplane weight. The airplane empty weight is compared to the 170B and the gross weight is considered to be the same as the 170B, which is 2200 pounds.

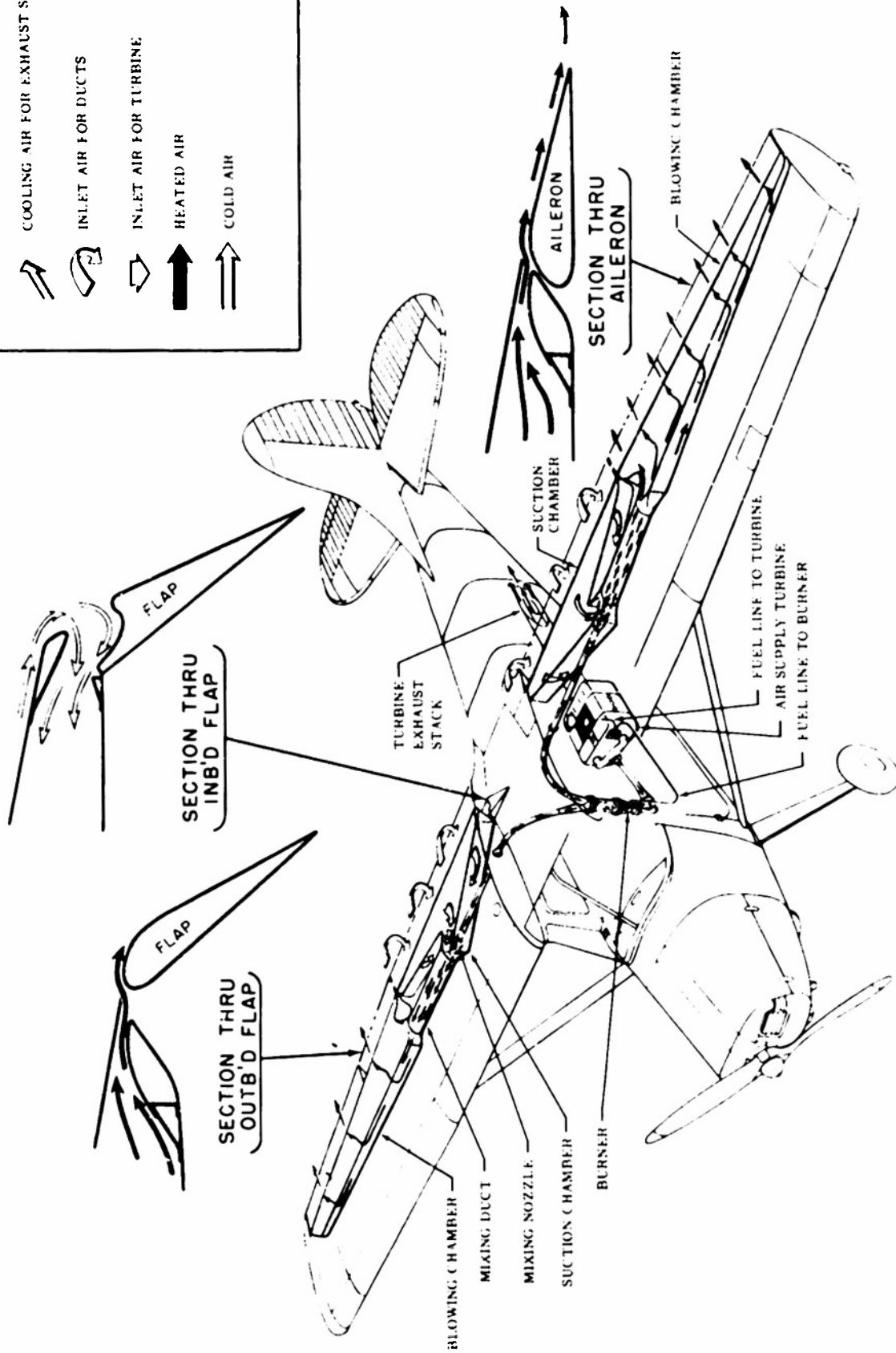
Item	Remarks	WT. LB.
Airplane		
Model 309	Empty	1530
Model 170B	Empty	<u>1190</u>
	Total Increase	340
Wing		
Model 309	One panel - complete	156
Model 170B	One panel - complete	<u>119</u>
	Increase per panel	37
Strut		
		11
Fuselage		
Model 170B	Fuselage - ready for structural modification and system installation	906
Air Supply System Includes controls and minimum required instrumentation 273		
Structure	Additional required for fuselage modification	<u>17</u>
Model 309	Includes empennage and complete system installation	1196
	Total weight of installation	290

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CODE

-  COOLING AIR FOR EXHAUST STACK
-  INLET AIR FOR DUCTS
-  INLET AIR FOR TURBINE
-  HEATED AIR
-  COLD AIR



CIRCULATION CONTROL
SYSTEM FOR CESSNA
MODEL 170A

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2



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FIG 3

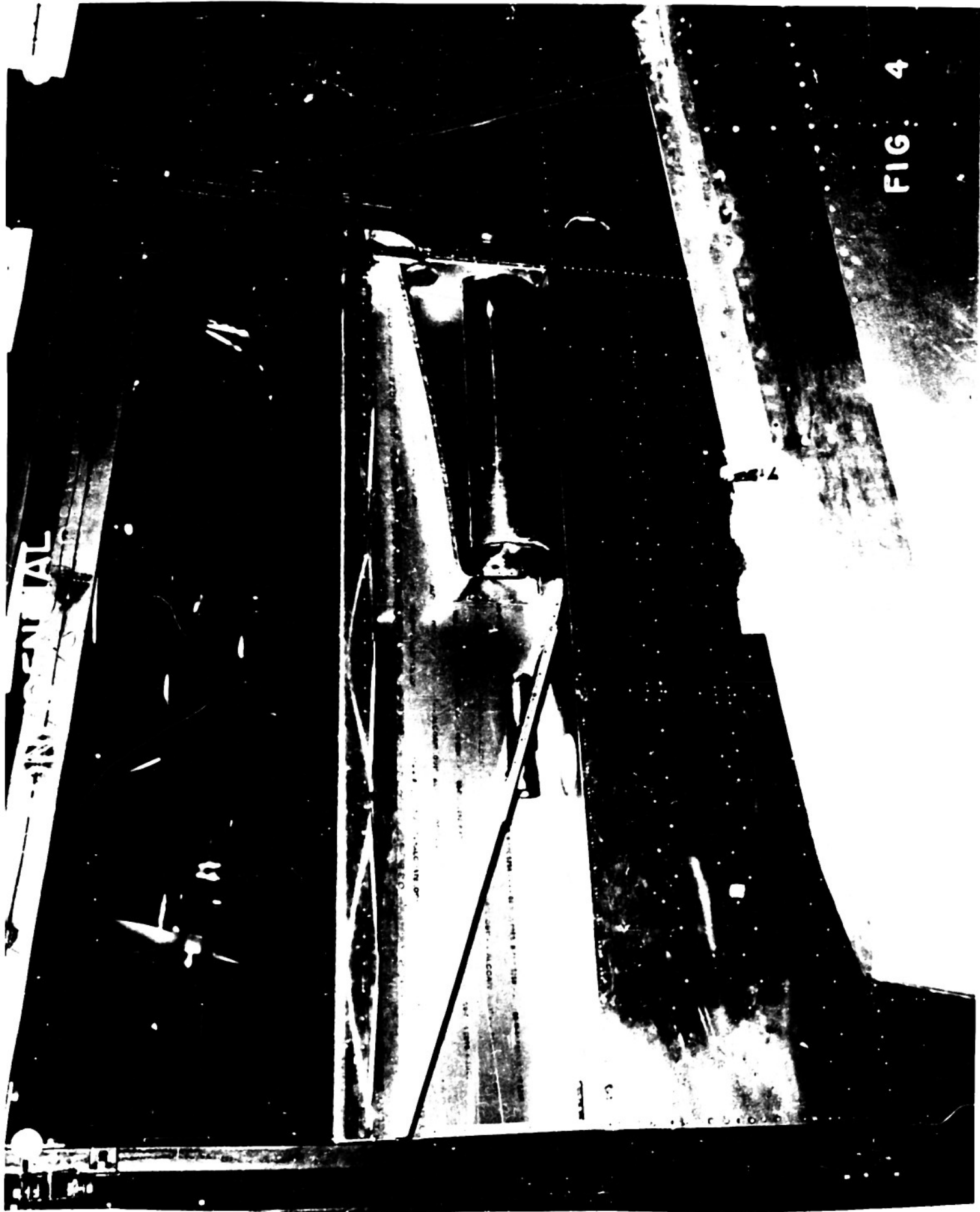


FIG. 4

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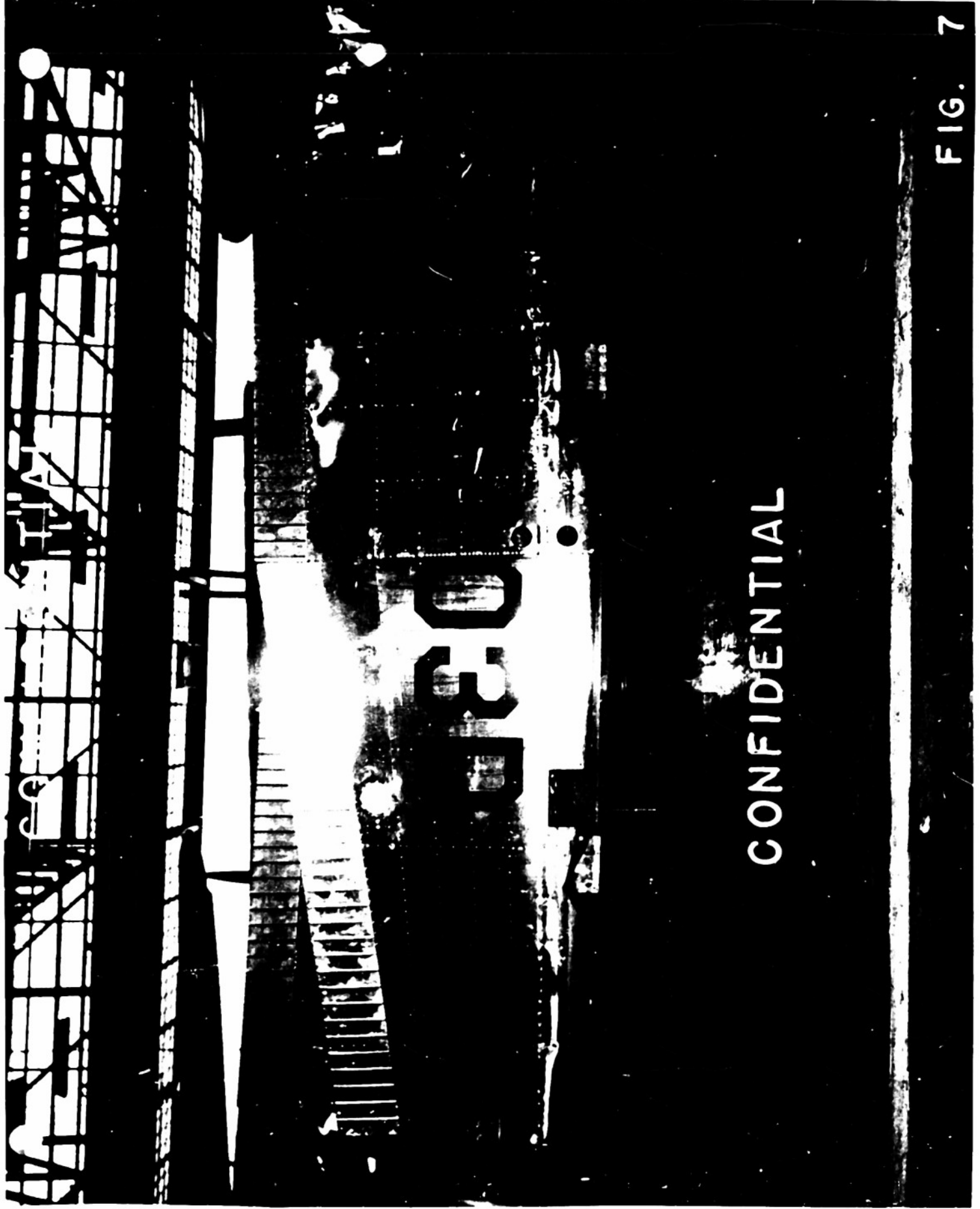
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FIG. 5

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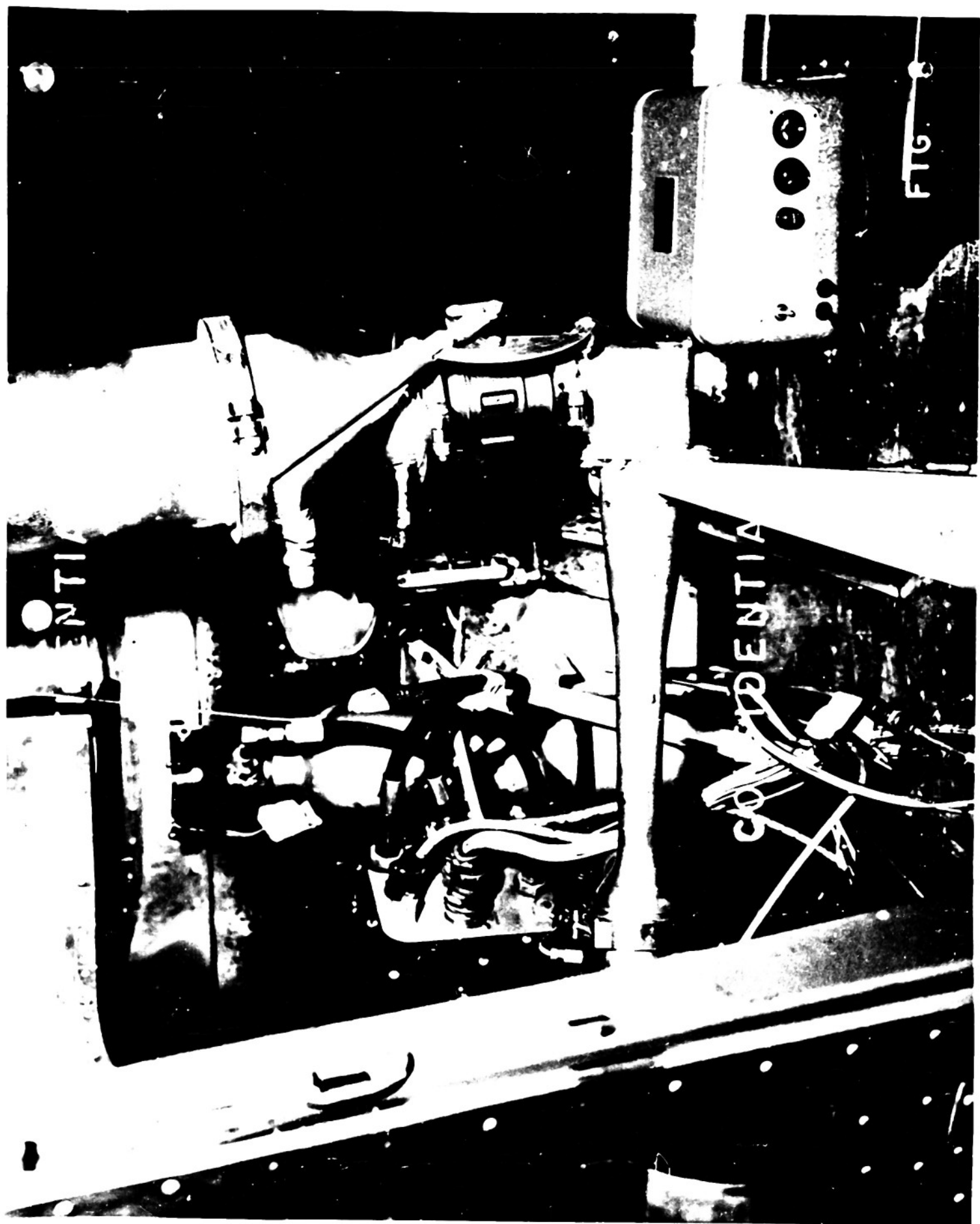


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FIG. 7



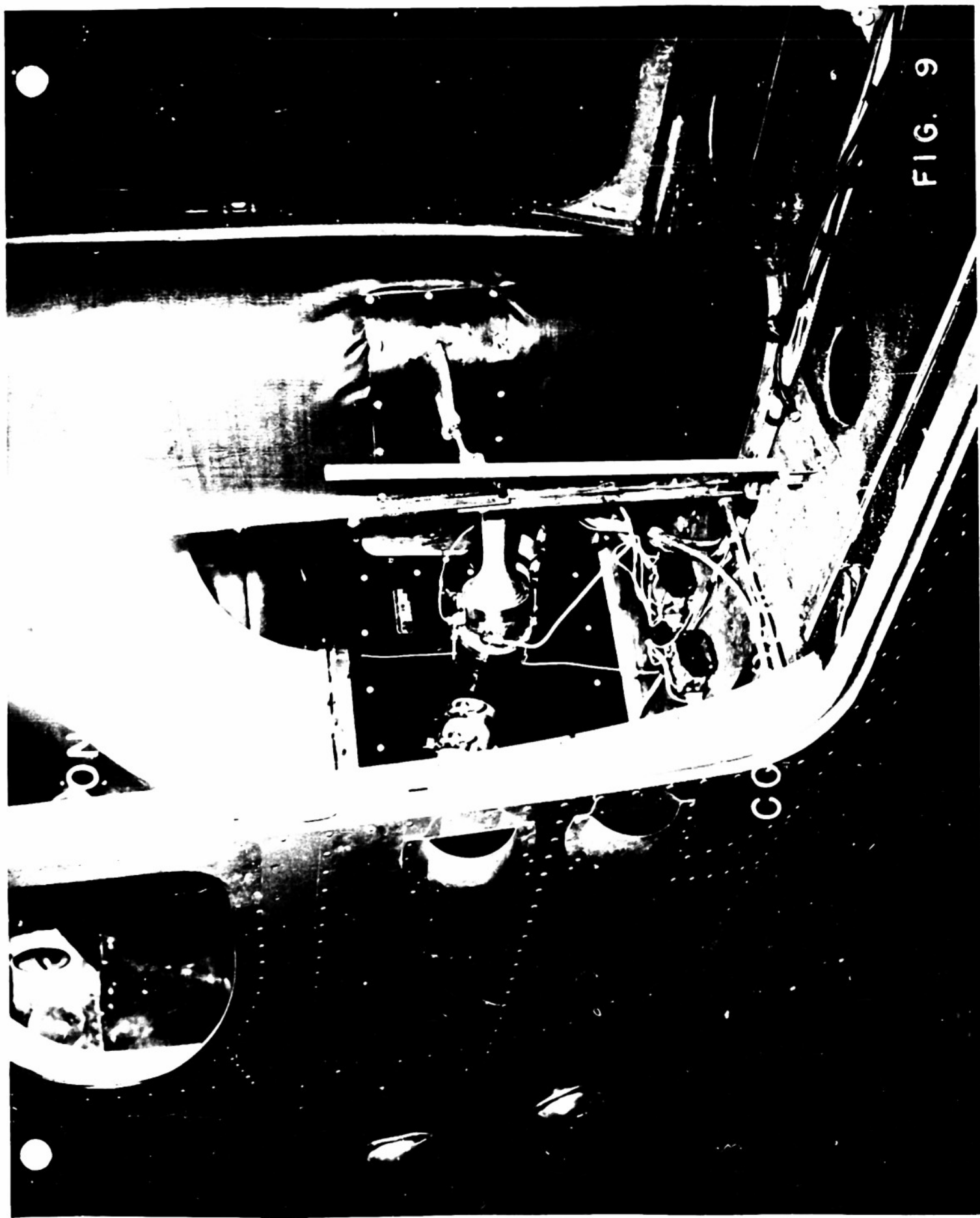
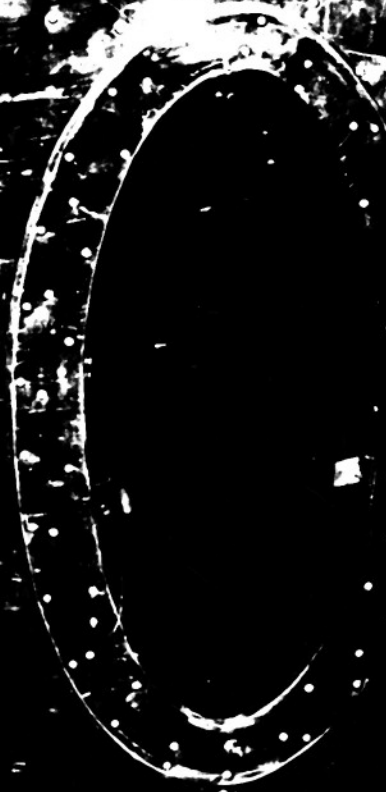


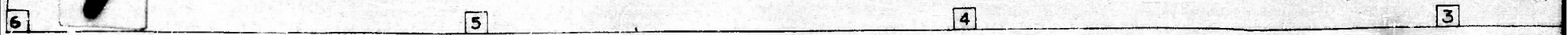
FIG. 9

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FIG. 10



ENGINE

CONTINENTAL MODEL C-145-B

145 HP AT 2700 RPM

CIRCULATION CONTROL SYSTEM

SPECIFICATION NO. 1309-1-1

AREAS

WING (INCLUDING FUSELAGE)	173.84 SQ. FT.
AILERON	11.72 SQ. FT.
FLAP	23.36 SQ. FT.
STABILIZER	18.226 SQ. FT.
FIN	8.70 SQ. FT.
ELEVATOR	13.864 SQ. FT.
RUDDER	8.41 SQ. FT.

CONTROL SURFACE TRAVELS

	UP	DOWN
ELEVATOR	24° ± 0	20° ± 0
ELEVATOR TAB	17° ± 0	25° ± 0
AILERON	20° ± 1	14° ± 1
AILERON DROOP	0°	-10° - 20° - 30°
FLAPS	0°	-15° - 24° - 30° - 50°
RUDDER	16° ± 1 LEFT	16° ± 1 RIGHT

GENERAL DATA

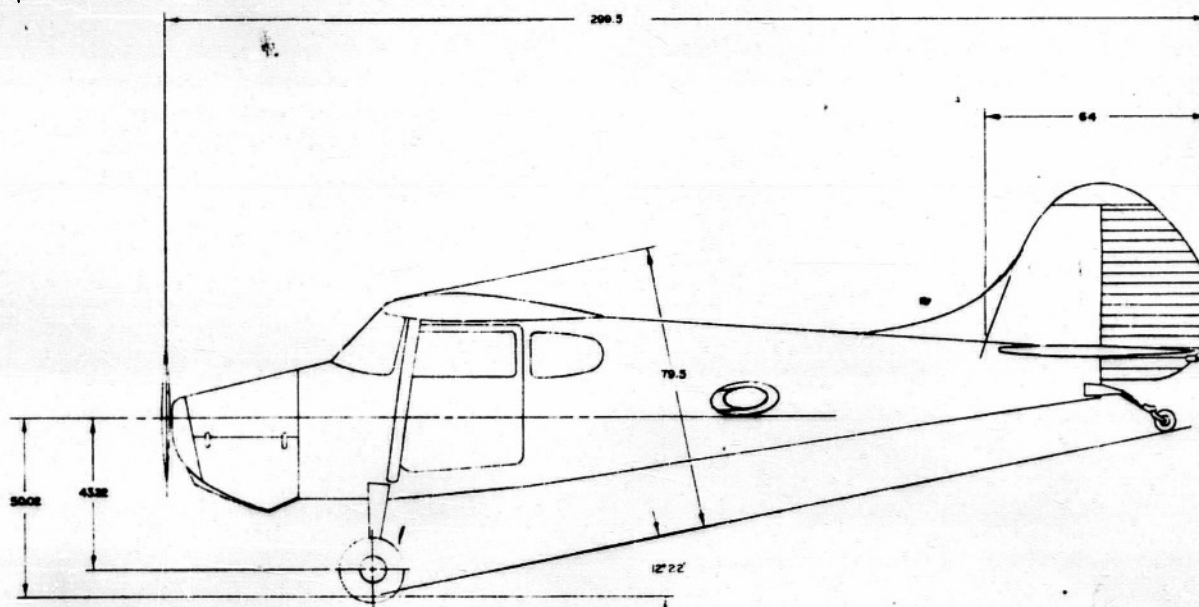
EMPTY WEIGHT	1330 LBS. APPROX.
GROSS WEIGHT	2200 LBS.
PROP. DIA. (MAX.)	78 IN.
WING AIRFOIL	NACA 2412
TAIL SURFACE AIRFOIL	NACA 0006

ANGLES OF INCIDENCE

WING - ROOT CHORD	+1° - 30'
TIP CHORD	+ 30'
STABILIZER	-4°

DIHEDRAL

WING	+ 30'
------	-------



12309-23

2

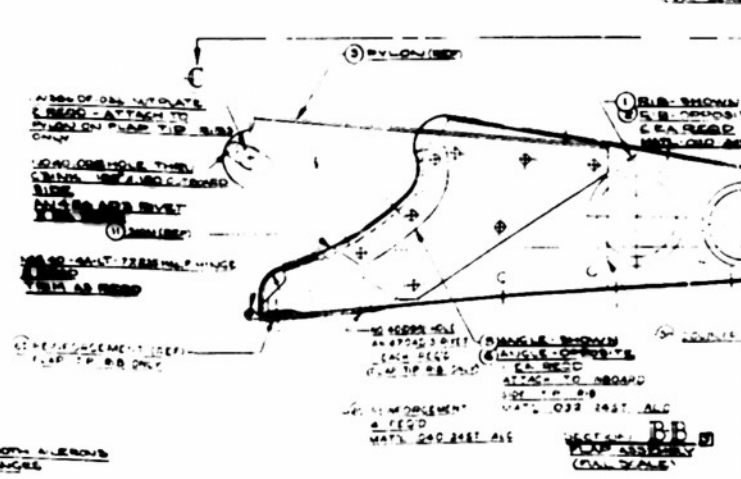
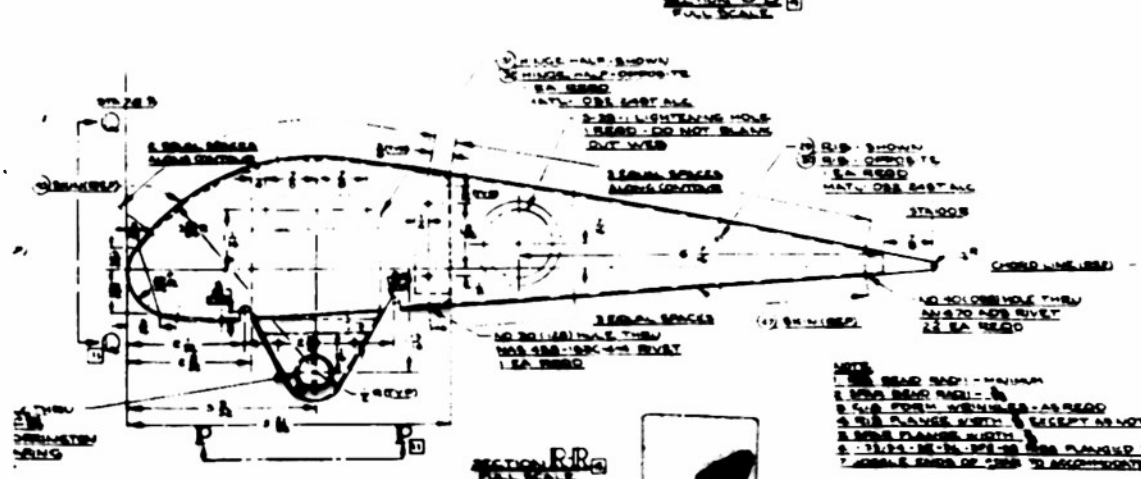
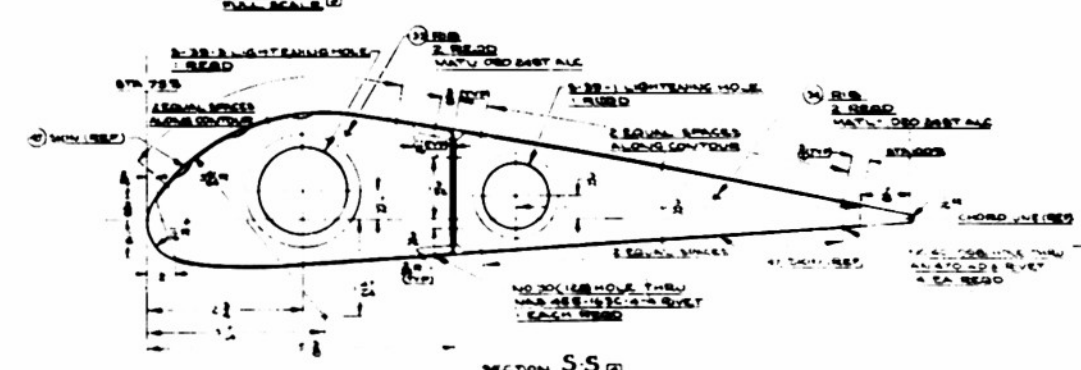
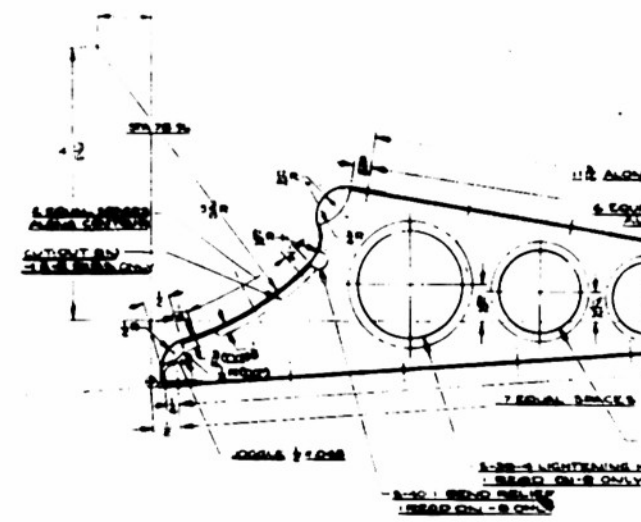
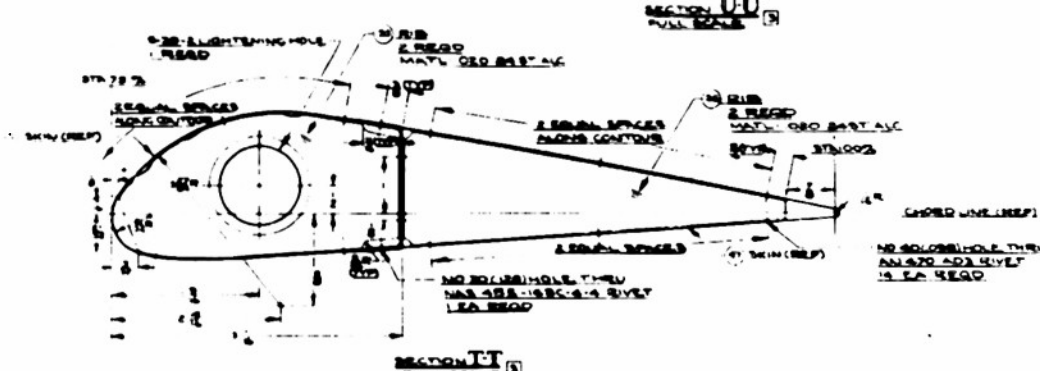
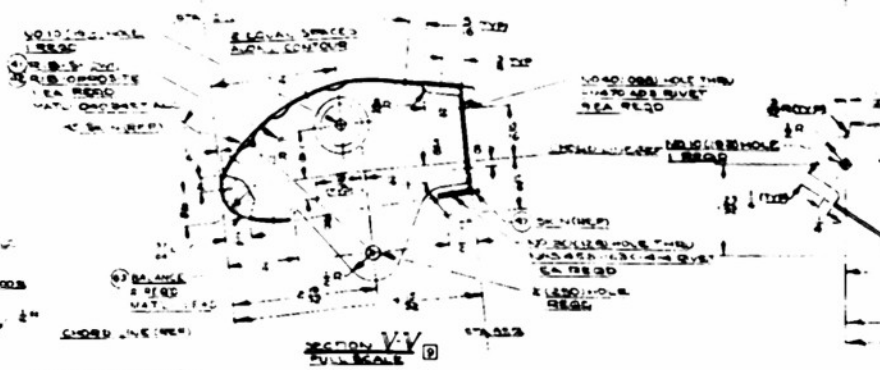
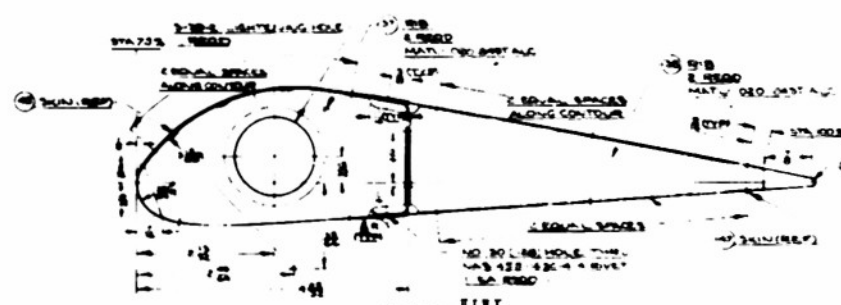
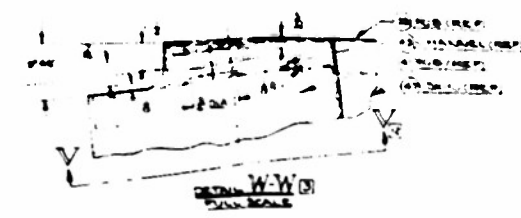
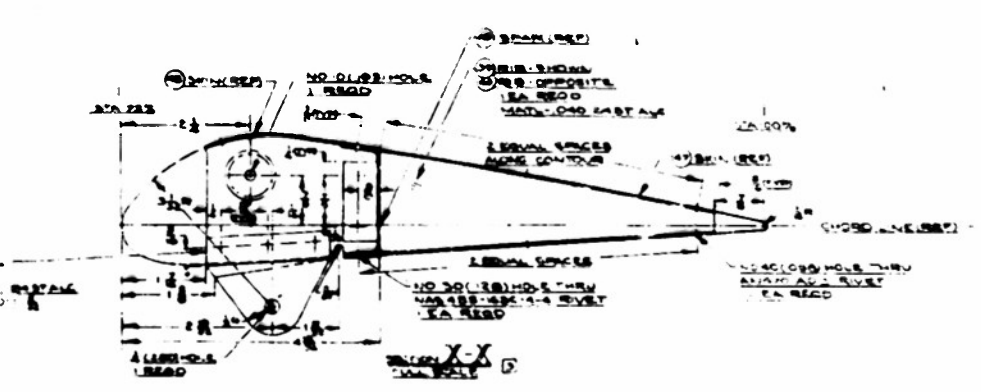
3

2

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DESIGNED BY E.A. LAUER		CHECKED BY HEINRICH		DATE 8-16-51		DATE 10-15-51		THREE VIEW		MODEL 309		GERBNA AIRCRAFT CO.		12309-23	
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SECTION R-R
FULL SCALE

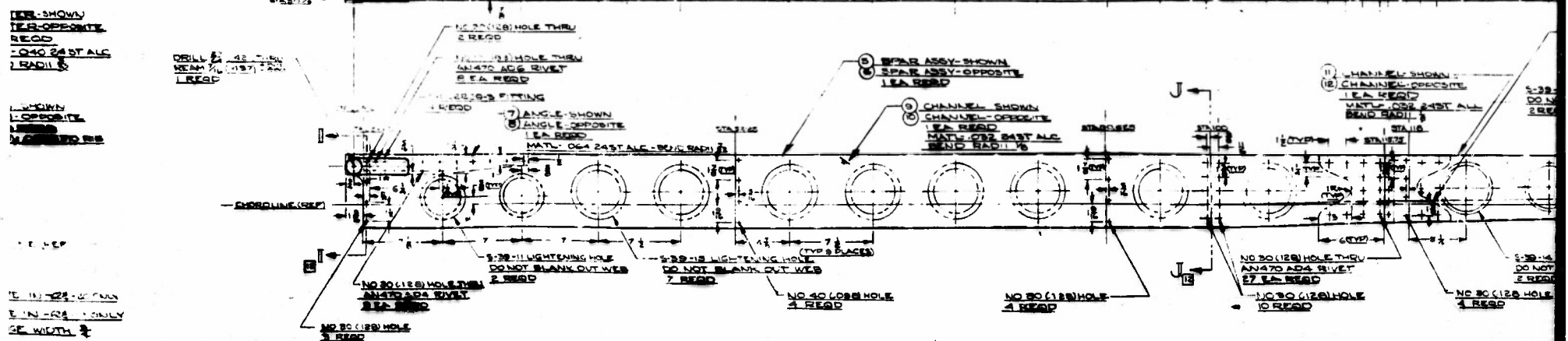
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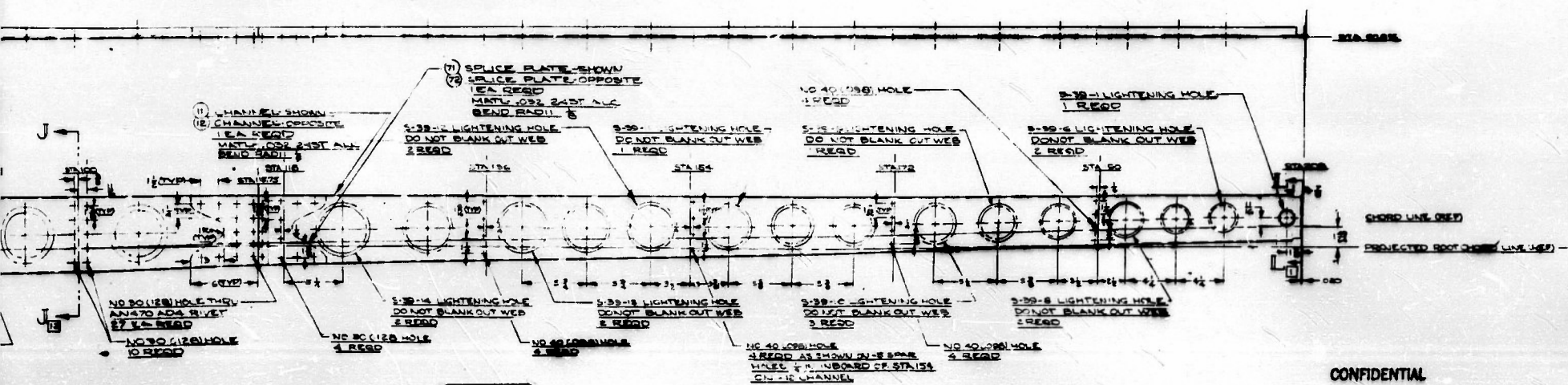
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8

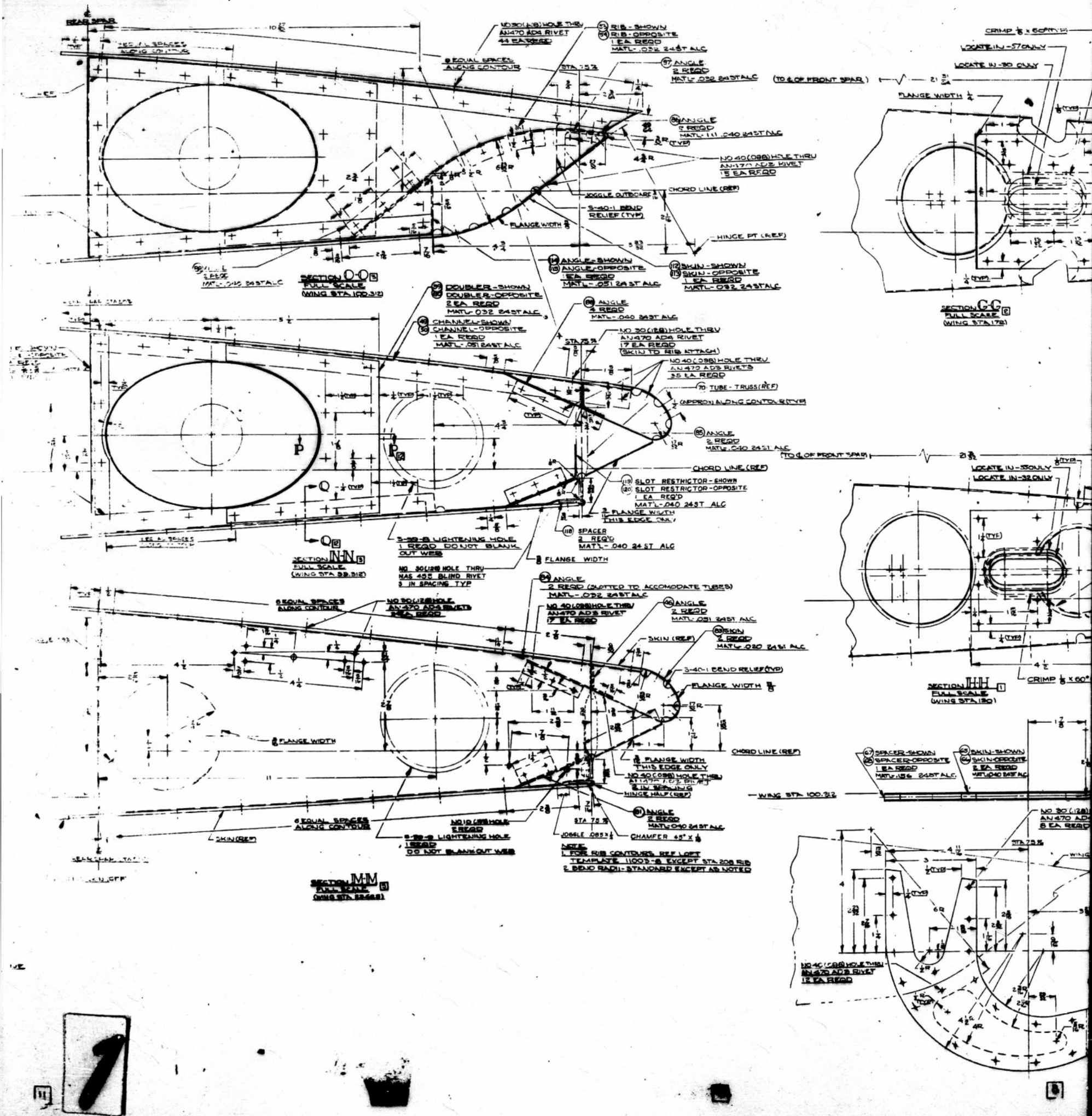
SECTION BB
FULL SCALE

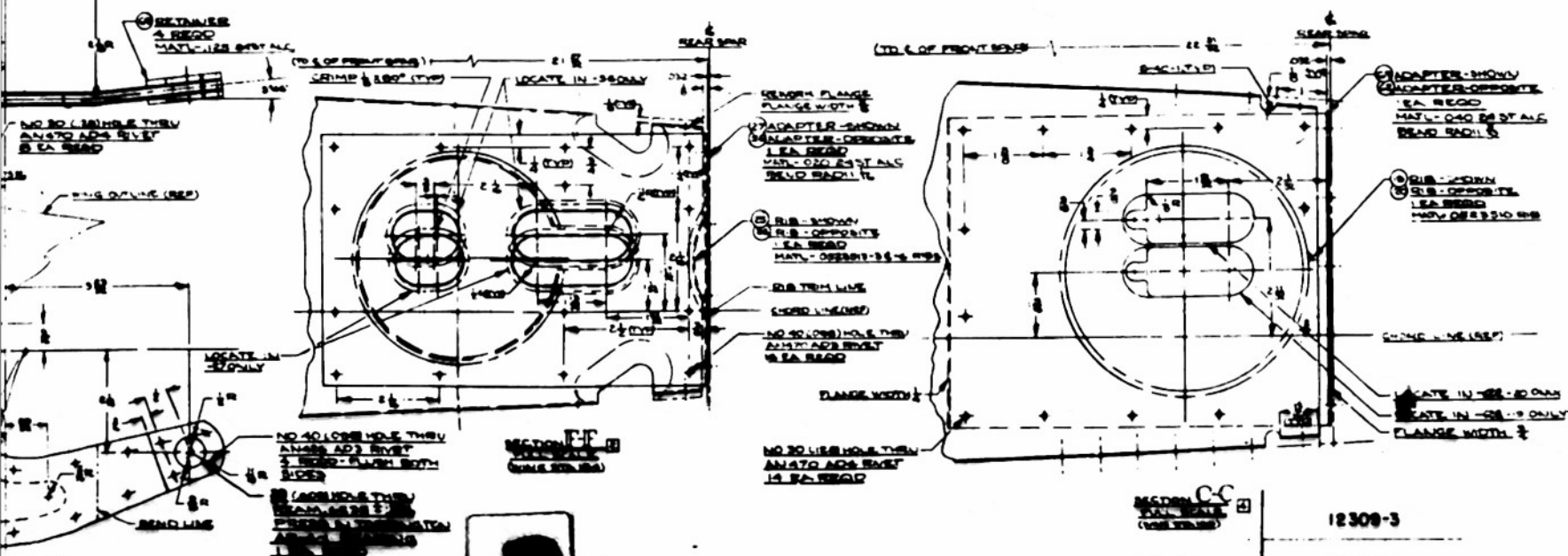
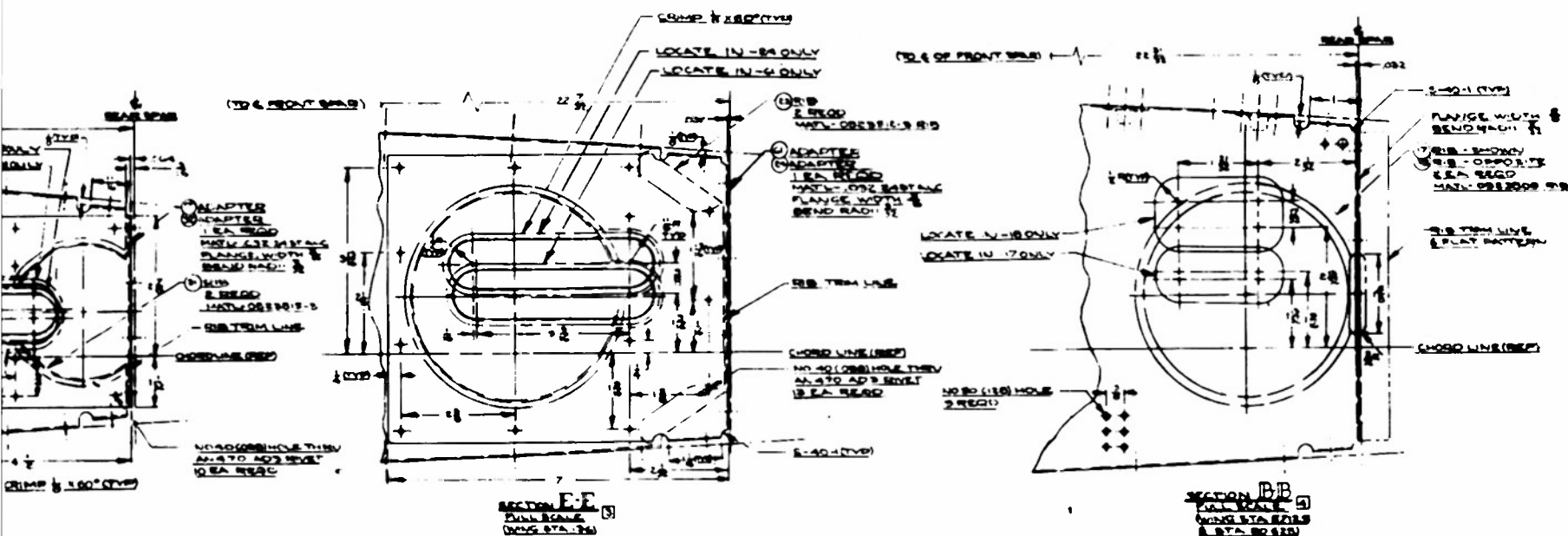
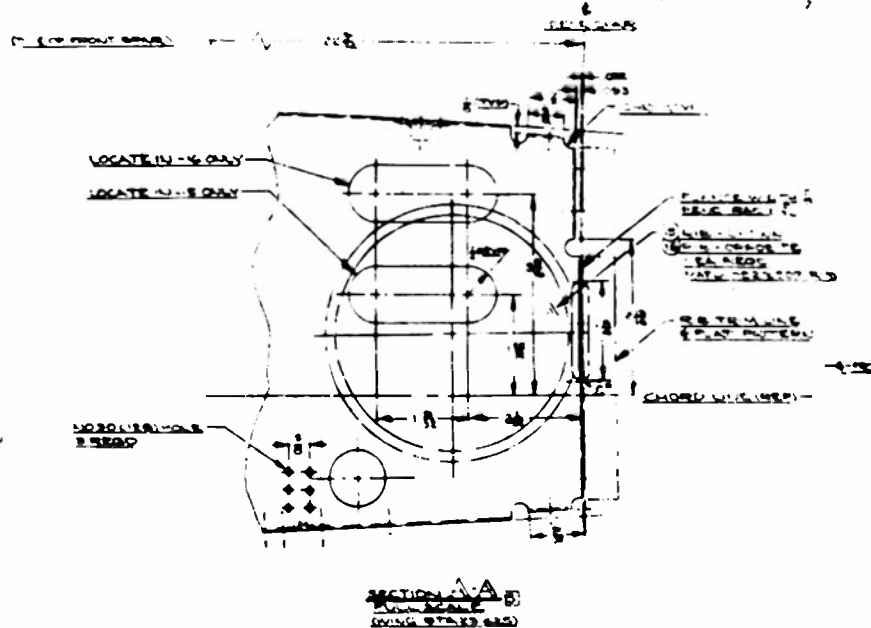


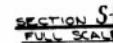
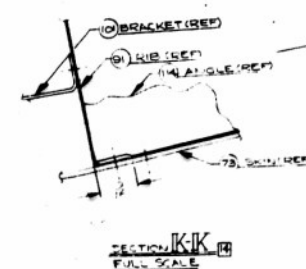
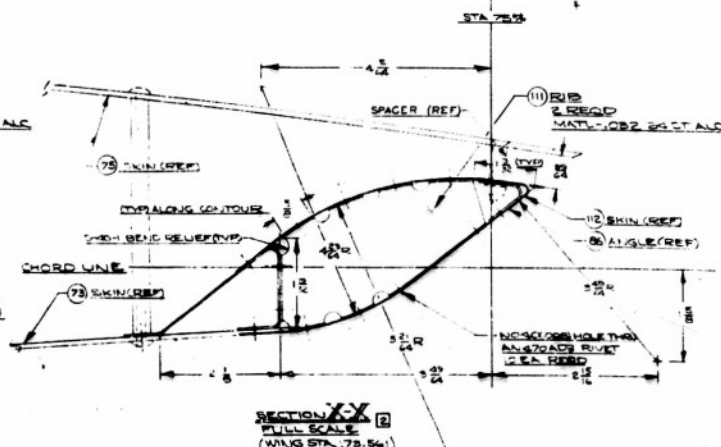
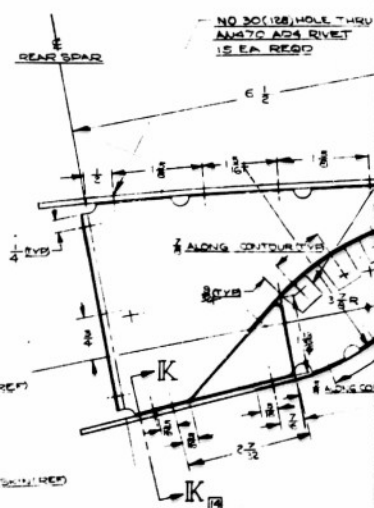
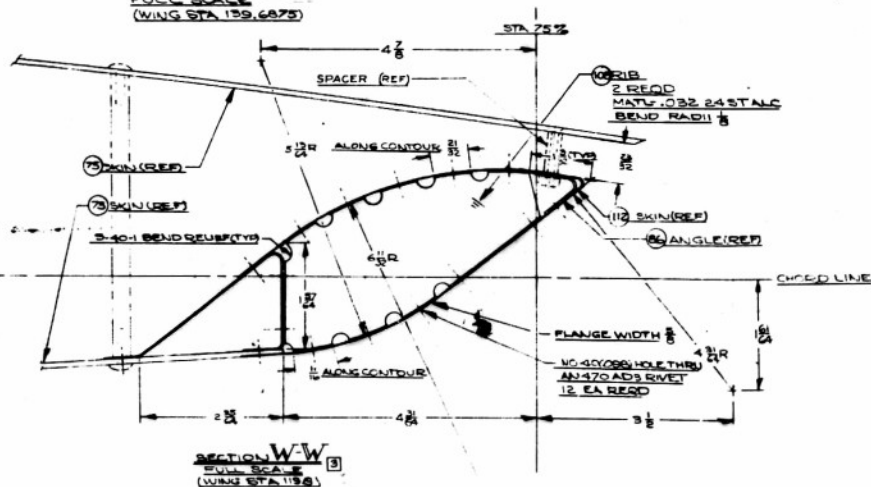
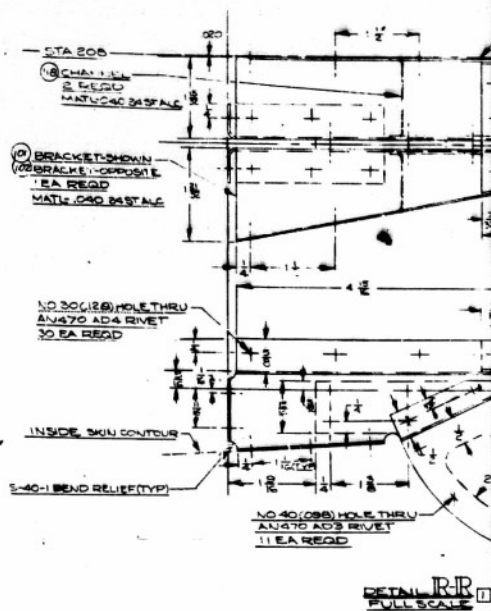


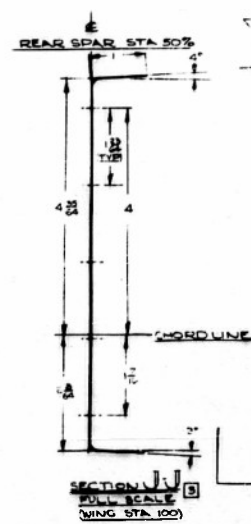
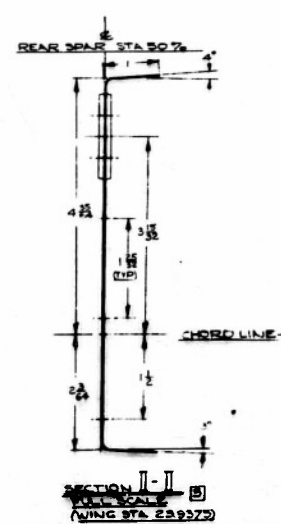
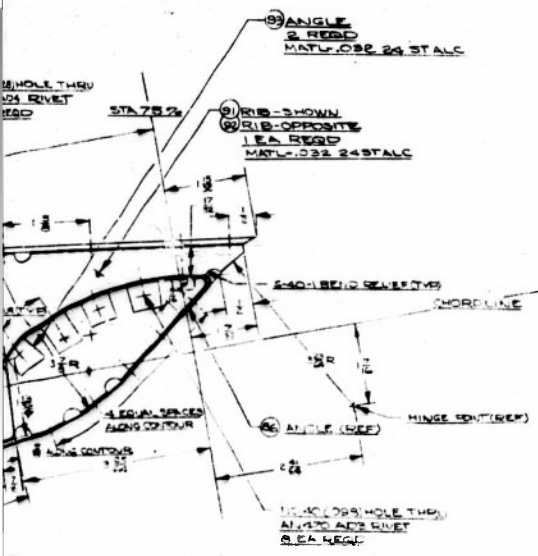
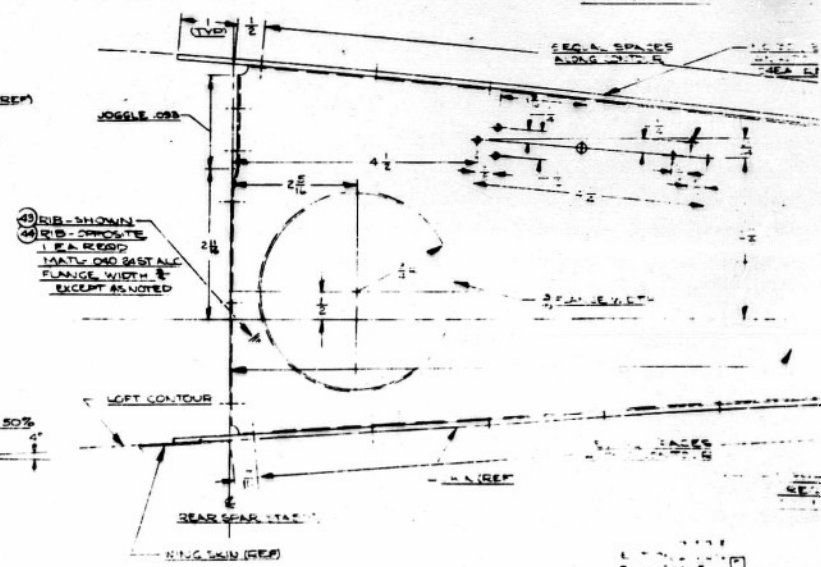
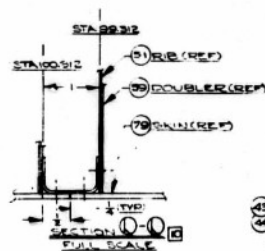
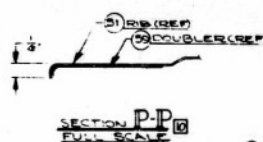
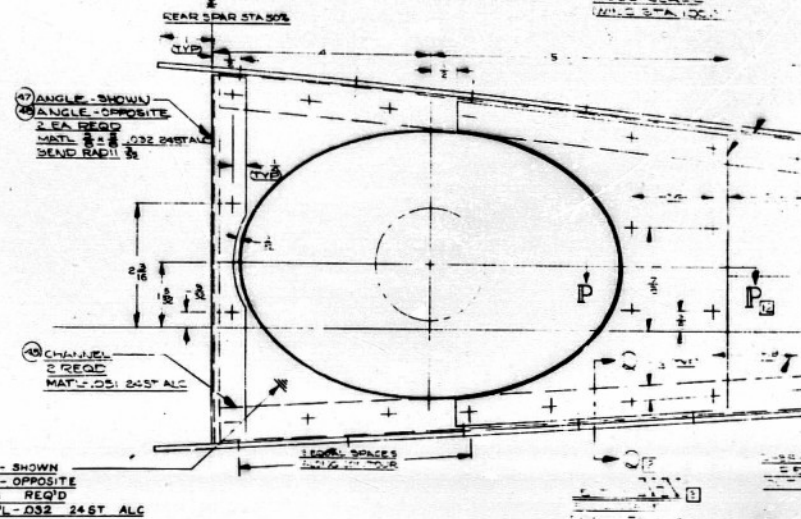
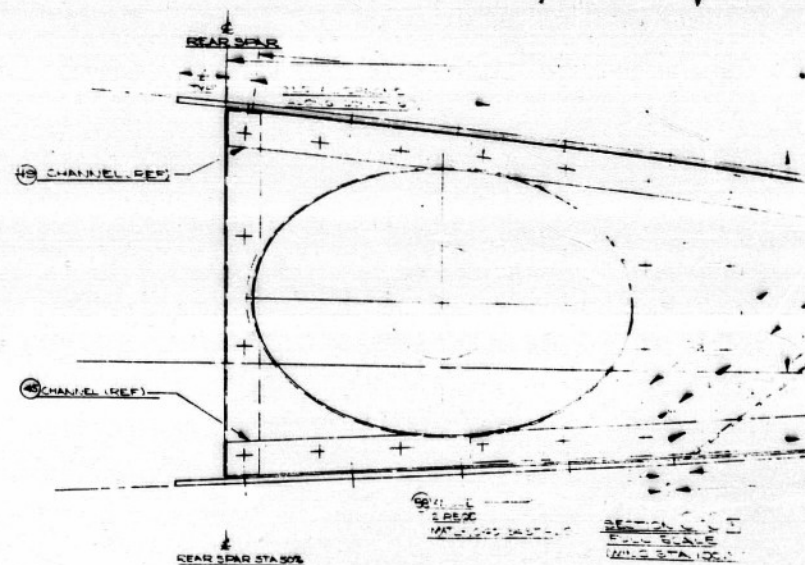
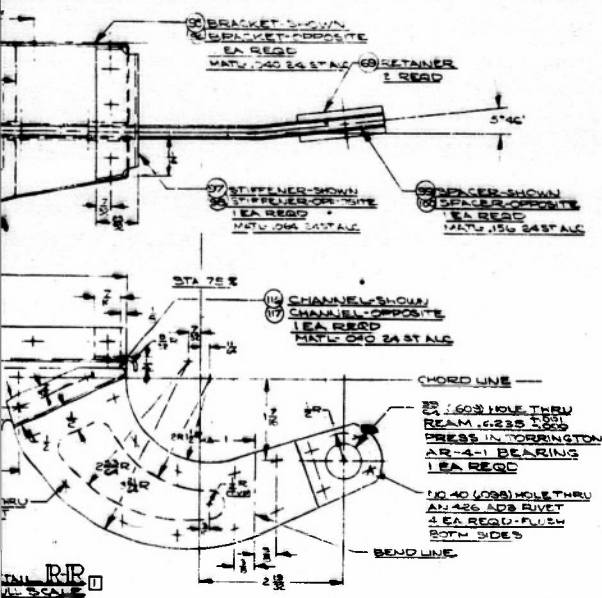


12309-3 B





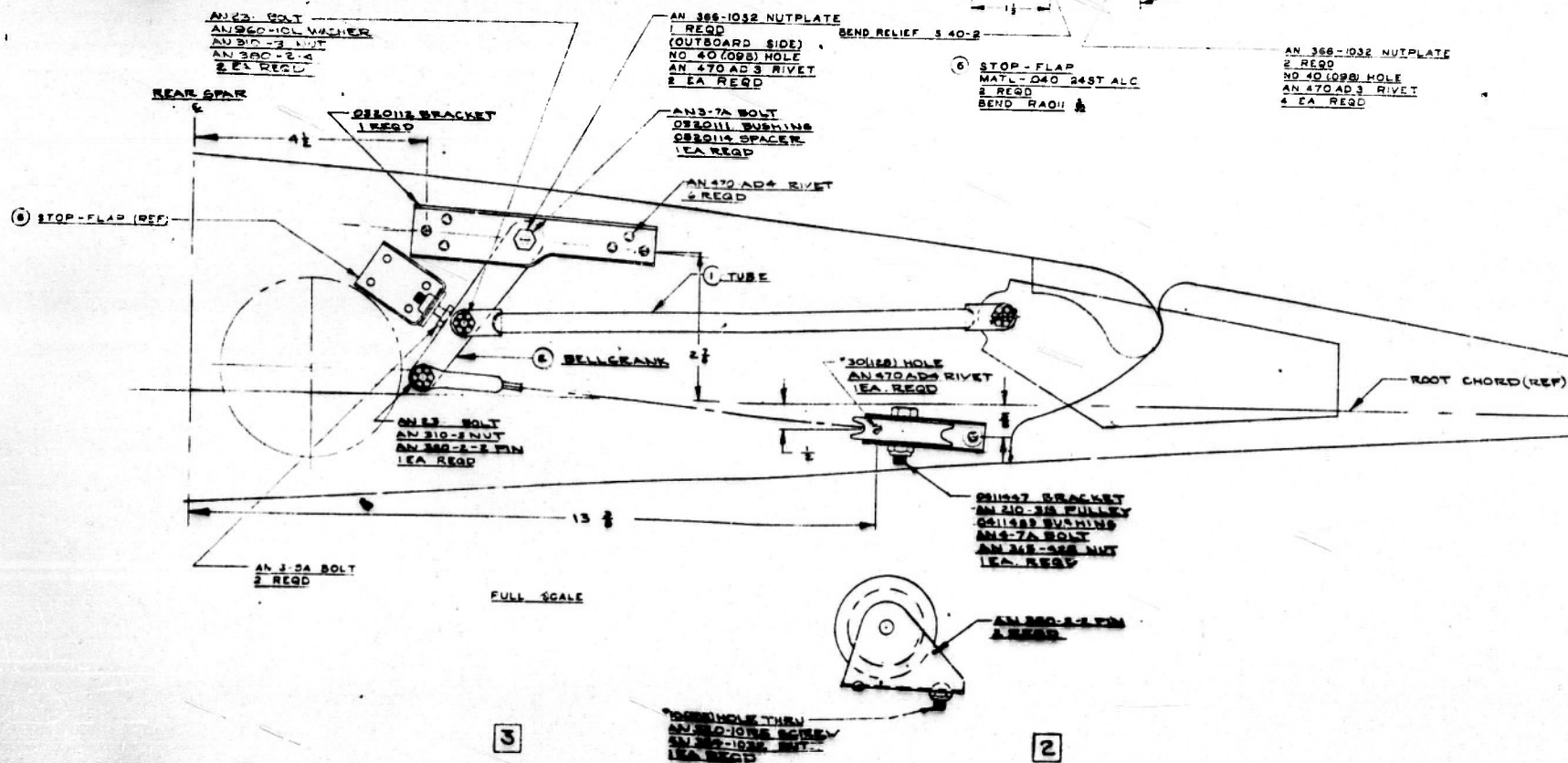
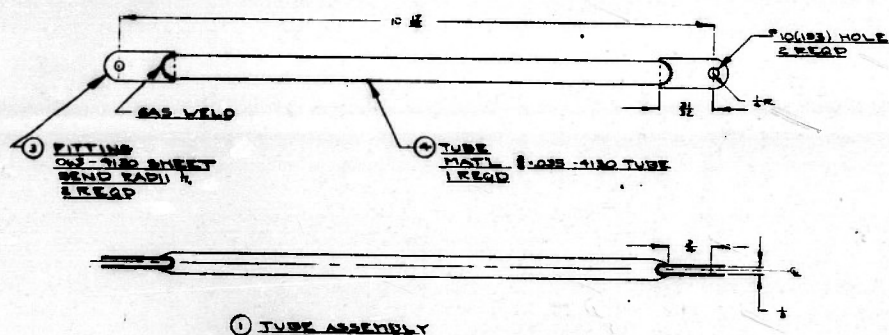
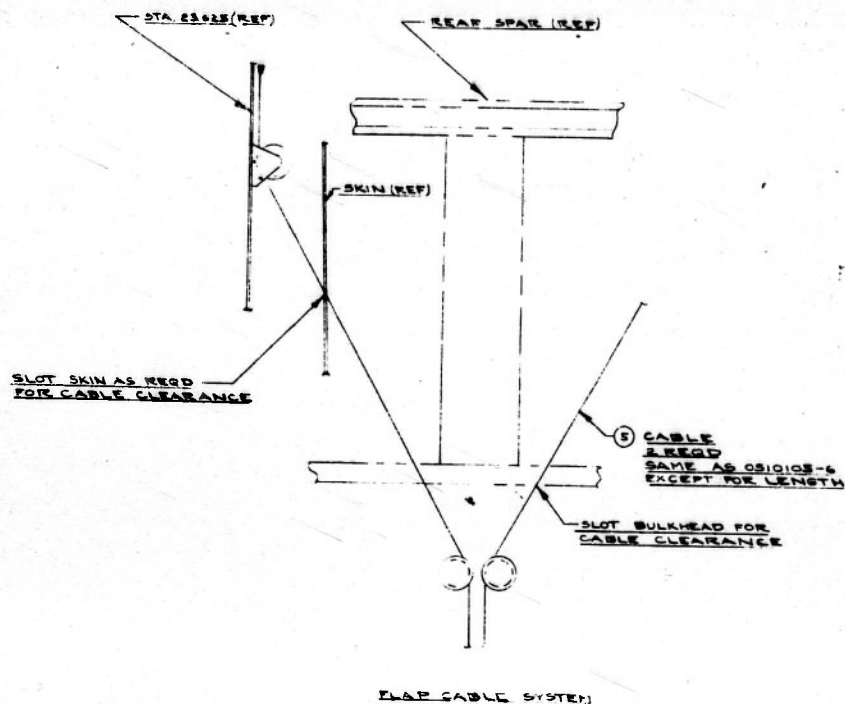
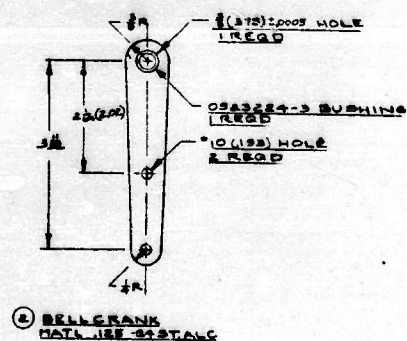




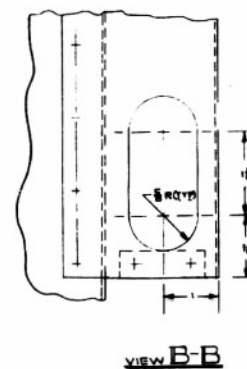
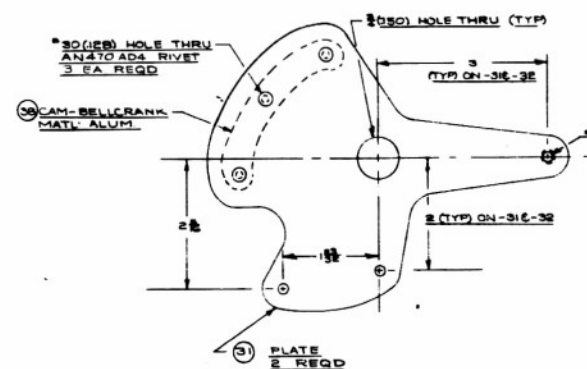
12309-3

SHEET 3

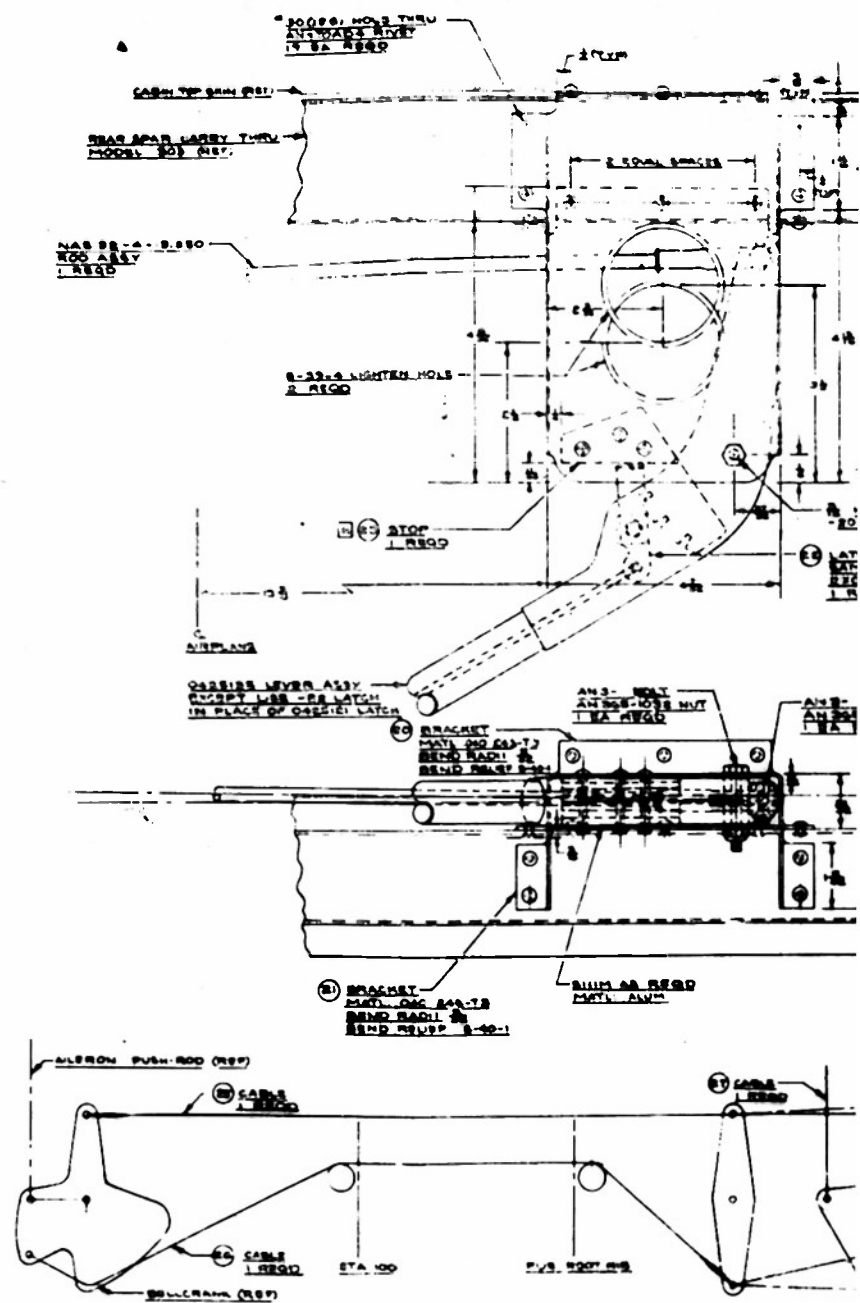
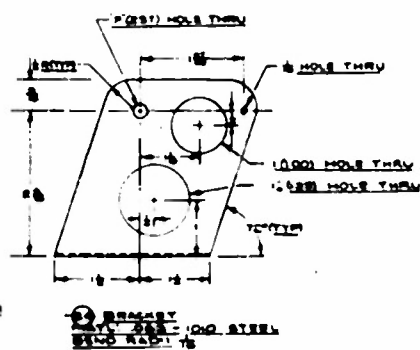
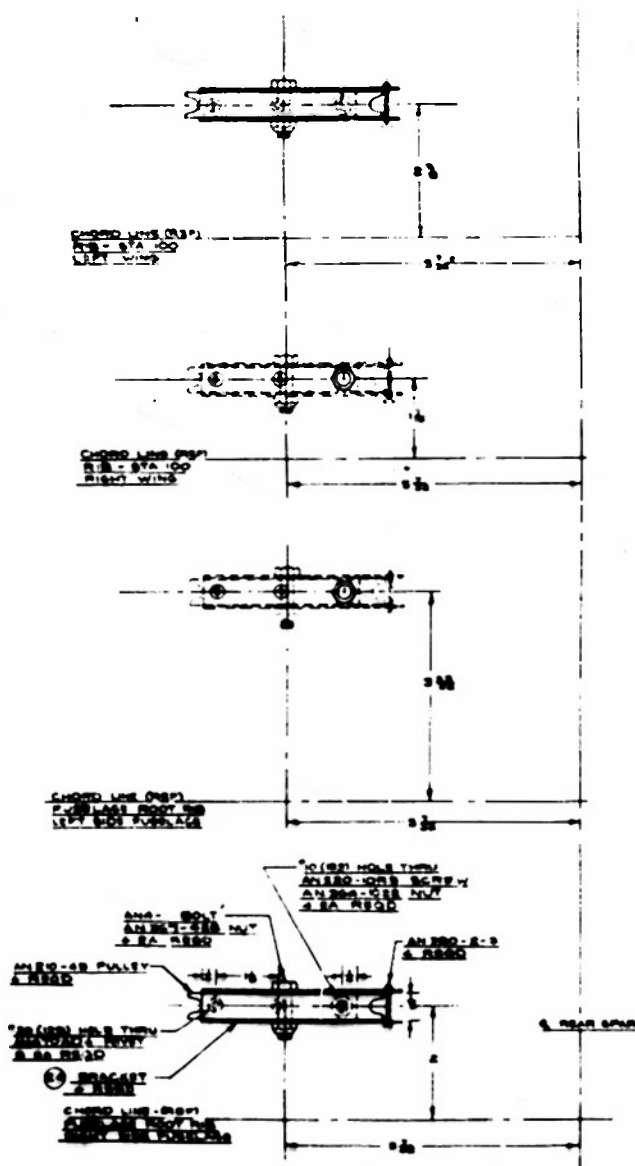
DASH NO	TITLE
5	FLAP CABLE

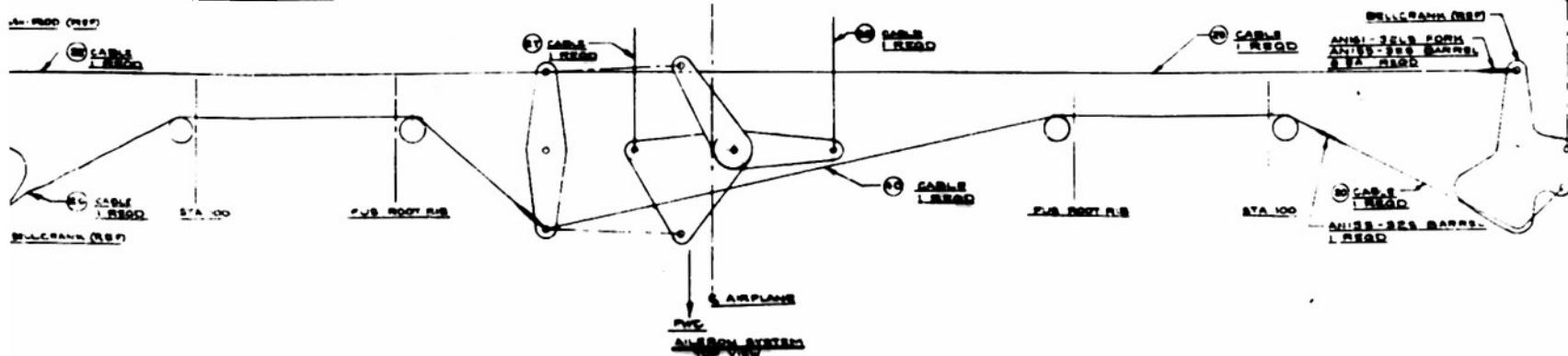
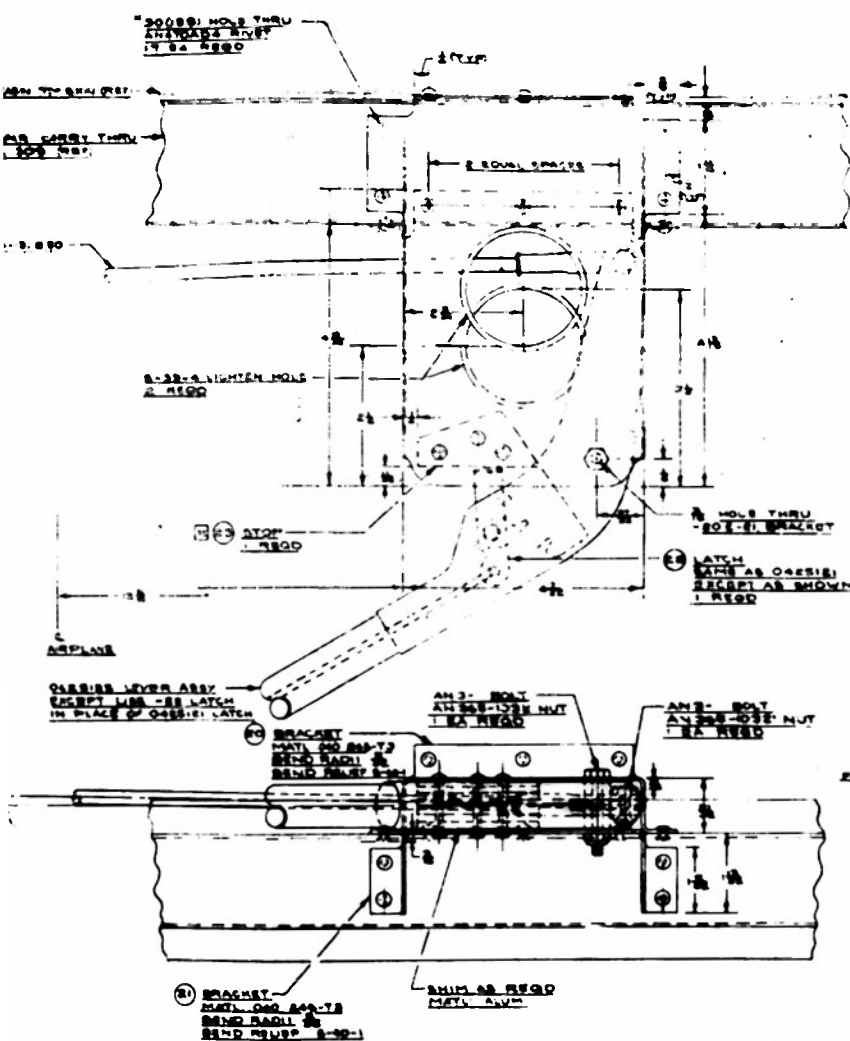


NOTE
1. FLAP TRAVEL 50"
2. USE 0523207 FLAP R
BETWEEN AFT END OF
ON FUSELAGE USING

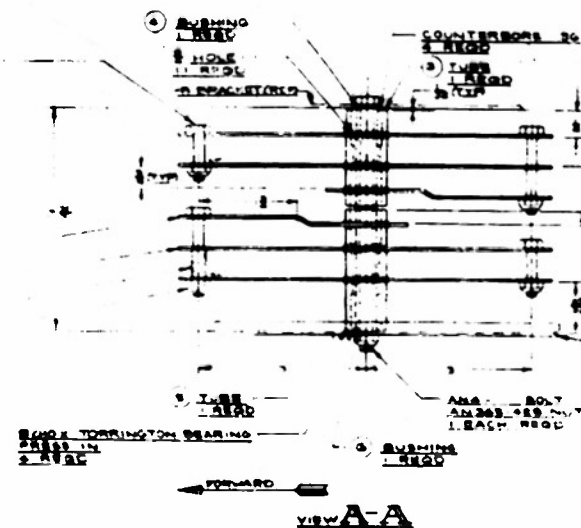


CHORD LINE





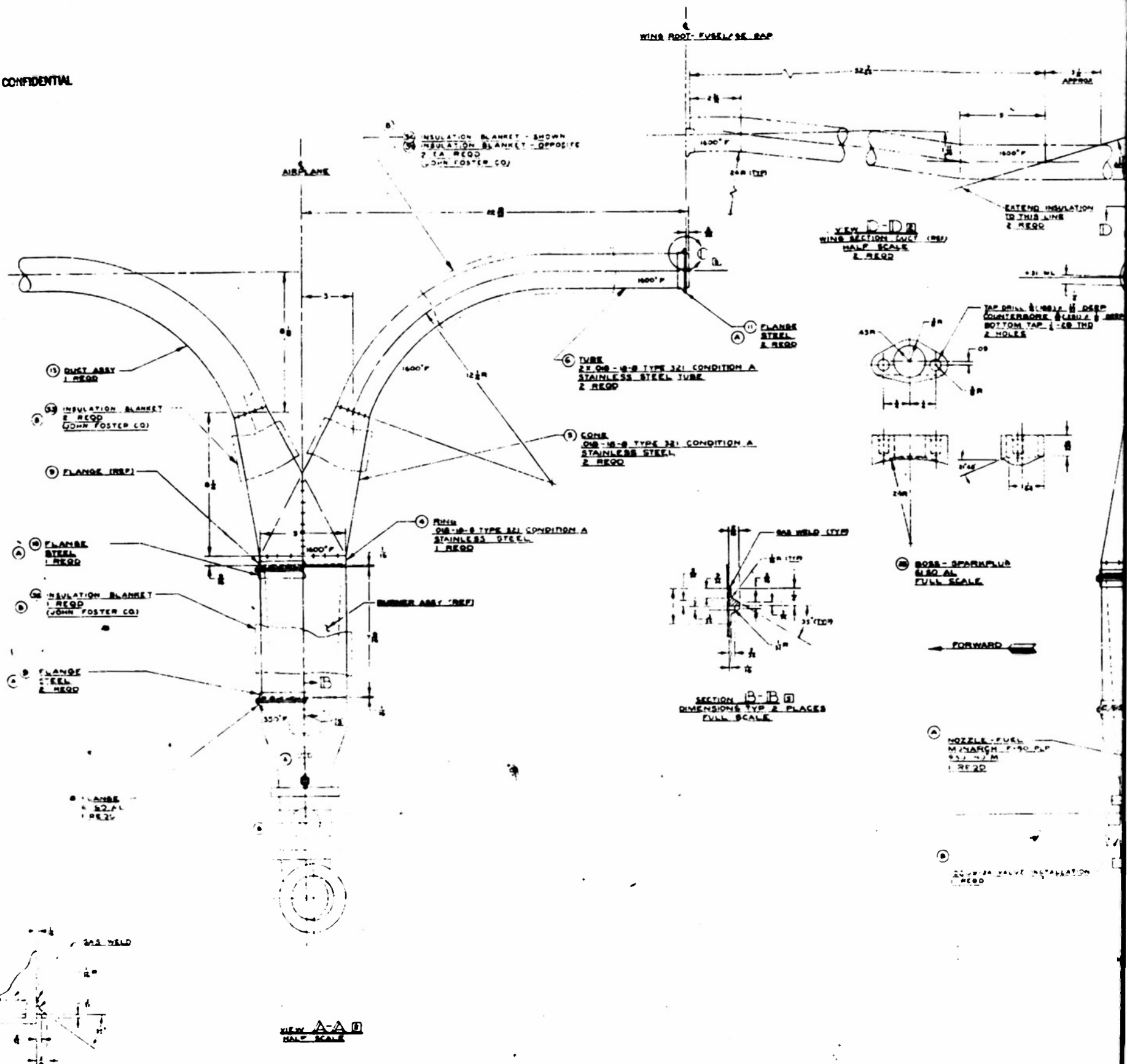
ANS. BOLT
AN308-108 NUT
1/4\"/>



CABLE NO.	SIZE	TERMINAL	TERMINAL
25	1/4"	ANCHOR-4	ANCHOR-4
26	1/4"	ANCHOR-4	ANCHOR-4
27	1/4"	ANCHOR-4	ANCHOR-4
28	1/4"	ANCHOR-4	ANCHOR-4
29	1/4"	ANCHOR-4	ANCHOR-4
30	1/4"	ANCHOR-4	ANCHOR-4
31	1/4"	ANCHOR-4	ANCHOR-4

ALL CABLES ARE 7/16\"/>

RECEIVED



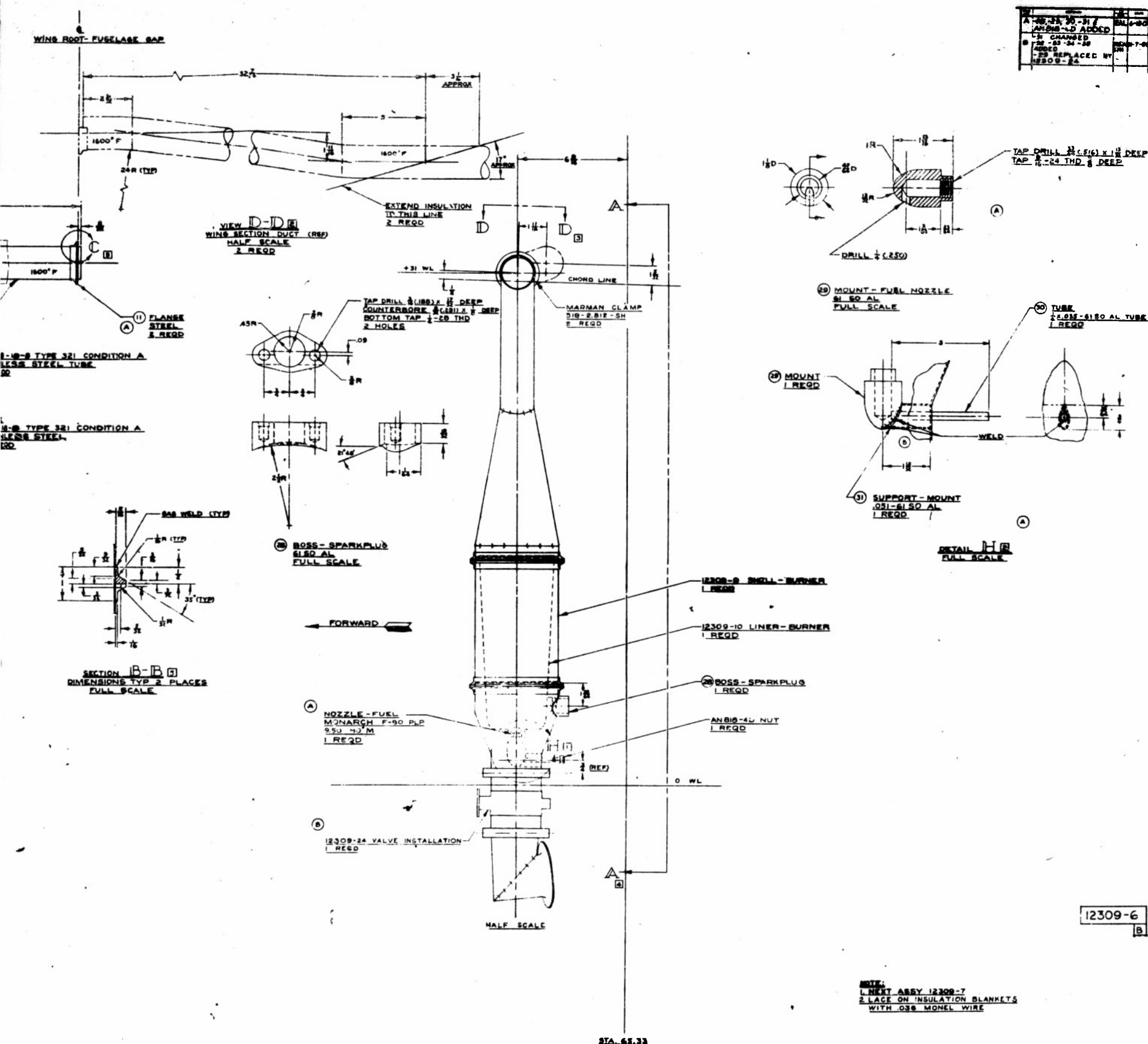
DEPARTMENT OF THE ARMY
HEADQUARTERS, U.S. ARMY
WASHINGTON, D.C.

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[5]

1

12309-6	12309-7
12309-8	12309-9
12309-10	12309-11
12309-12	12309-13
12309-14	12309-15
12309-16	12309-17
12309-18	12309-19
12309-20	12309-21
12309-22	12309-23
12309-24	12309-25



12309-6

B

CONFIDENTIAL

DESIGNER	CESSNA AIRCRAFT CO.
FOR THE CUSTOMER	12309-6
DATE	1-16-61
BY	W. M. SALAS
CHECKED	W. M. SALAS
APPROVED	W. M. SALAS
12309-6	

ANBIS-80 NUT
ANBIS-80 NUT
ANBIS-80 NUT
2 EA REQD

ANBIS-80 FLUR
1 REQD
ANBIS-80 ELBOW
2 REQD

2-1/2" 3-1/2" RUBBER TUBING
1 EA REQD

ADAPTER
2-1/2" 3-1/2" ALG
1 REQD

QUINER STRAINER
1 REQD

NO 10/18/18 HOLE THRU
ANBIS-80 RIVET
10 EA REQD

ANBIS-80 BOLT
ANBIS-80 WASHER
ANBIS-80 NUT
2 EA REQD

ANBIS-80 NUT
ANBIS-80 NUT
1 EA REQD

VIEW H-H
FULL SCALE

ADAPTER WINDOW
1 REQD
MAY 1950 2-1/2" 3-1/2" ALG

TUBE
2-1/2" 3-1/2" ALG
1 REQD

DUCT - WTAPE
1 REQD
MAY 1950 2-1/2" 3-1/2" ALG
CROSS SECTION AREA OF
DUCT TO BE CONSTANT

DUCT-6 DUCT ASSEMBLY
1 REQD

AIRPLANE

MARMAN CLAMP
2-1/2" 3-1/2" ALG
2 REQD

SPARKPLUG (CHAMPION 6-6)
1 REQD

MARMAN CLAMP
2-1/2" 3-1/2" ALG
1 REQD

ANBIS-80 BOLT
ANBIS-80 WASHER
2 EA REQD

COMPRESSOR UNIT
ALBION 6703/44-2
1 REQD

MARMAN
2-1/2" 3-1/2" ALG
1 REQD

DUCT LINE (REF)

MARMAN CLAMP
2-1/2" 3-1/2" ALG
1 REQD

NOZZLE - FLOW LIMITING
ALBION 6703/44-2
1 REQD

MARMAN CLAMP
2-1/2" 3-1/2" ALG
1 REQD

MOUNT - SHOCK
1 REQD

ANBIS-80 UNION
ANBIS-80 NUT
ANBIS-80 BOLT
1 EA REQD

ASSY - SUPPORT
1 REQD

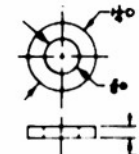
TUBE - DRAIN
2-1/2" 3-1/2" ALG
1 REQD

8-1/2" HOLE
ANBIS-80 RIVET
2 REQD

CLAMP
2-1/2" 3-1/2" ALG
1 REQD

TAPPIE (REF)

HALF SCALE



MOUNT - SHOCK
1 REQD
MAY 1950 2-1/2" 3-1/2" ALG
FULL SCALE

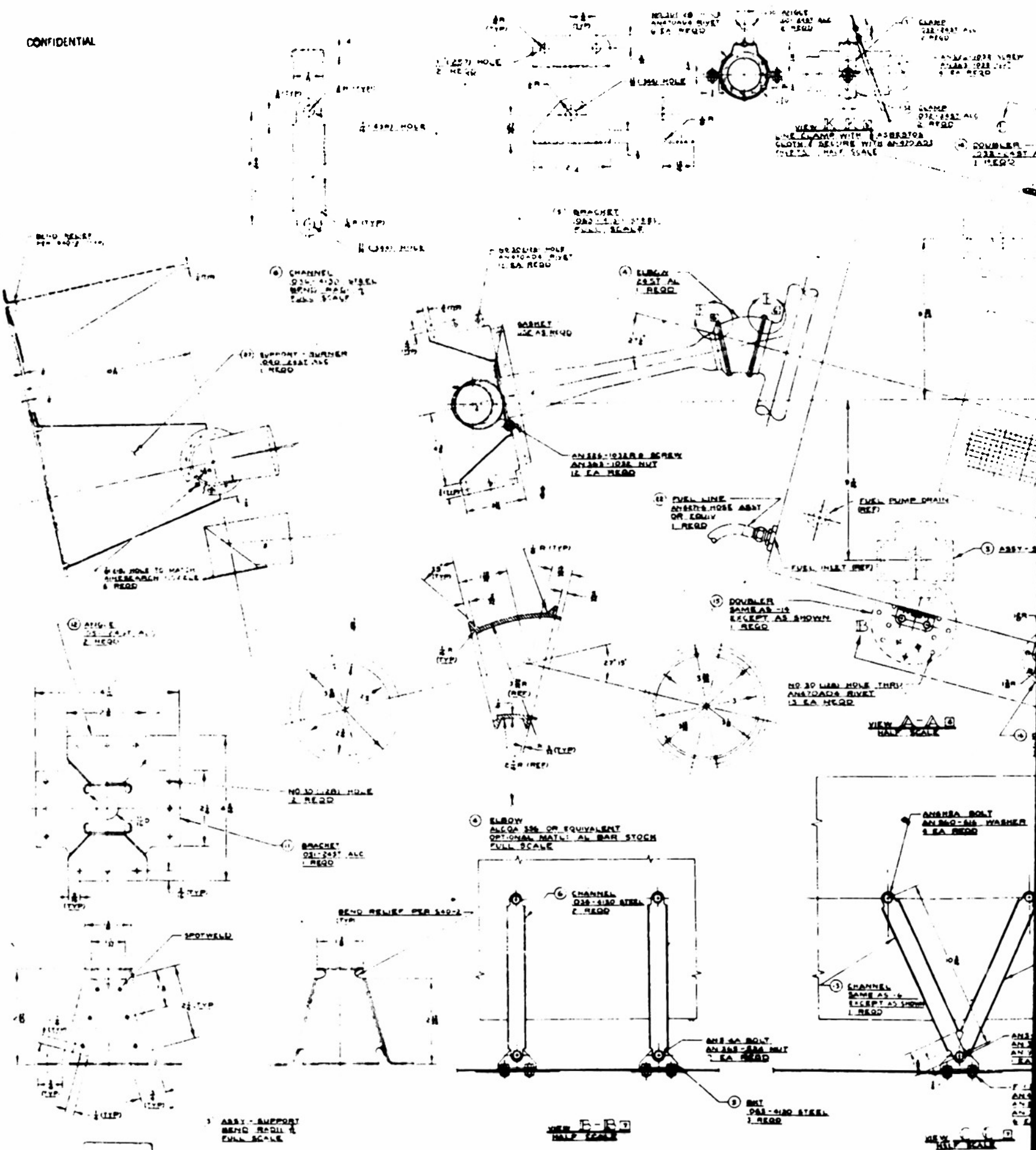
SECTION D-D
FULL SCALE

3

4

3

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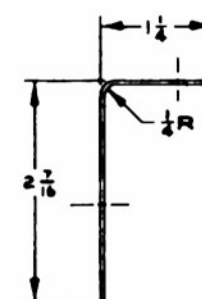
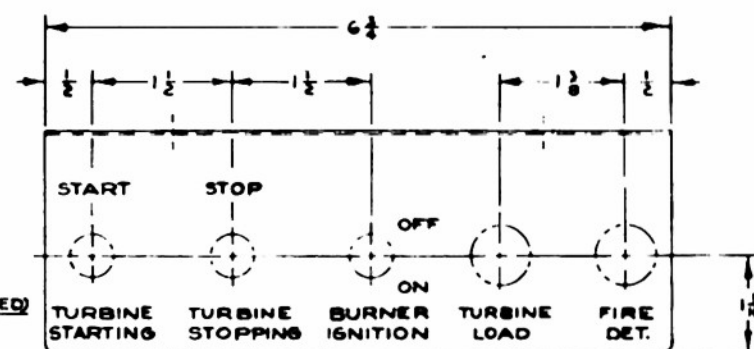
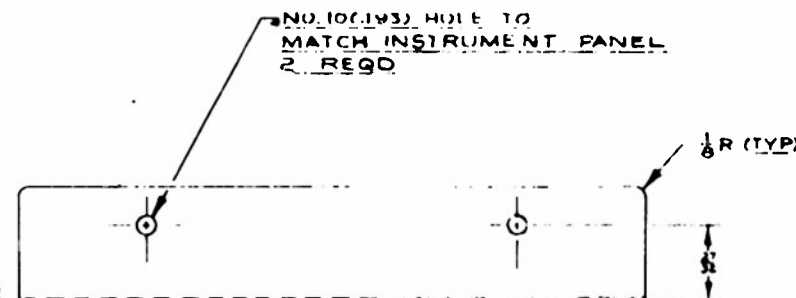
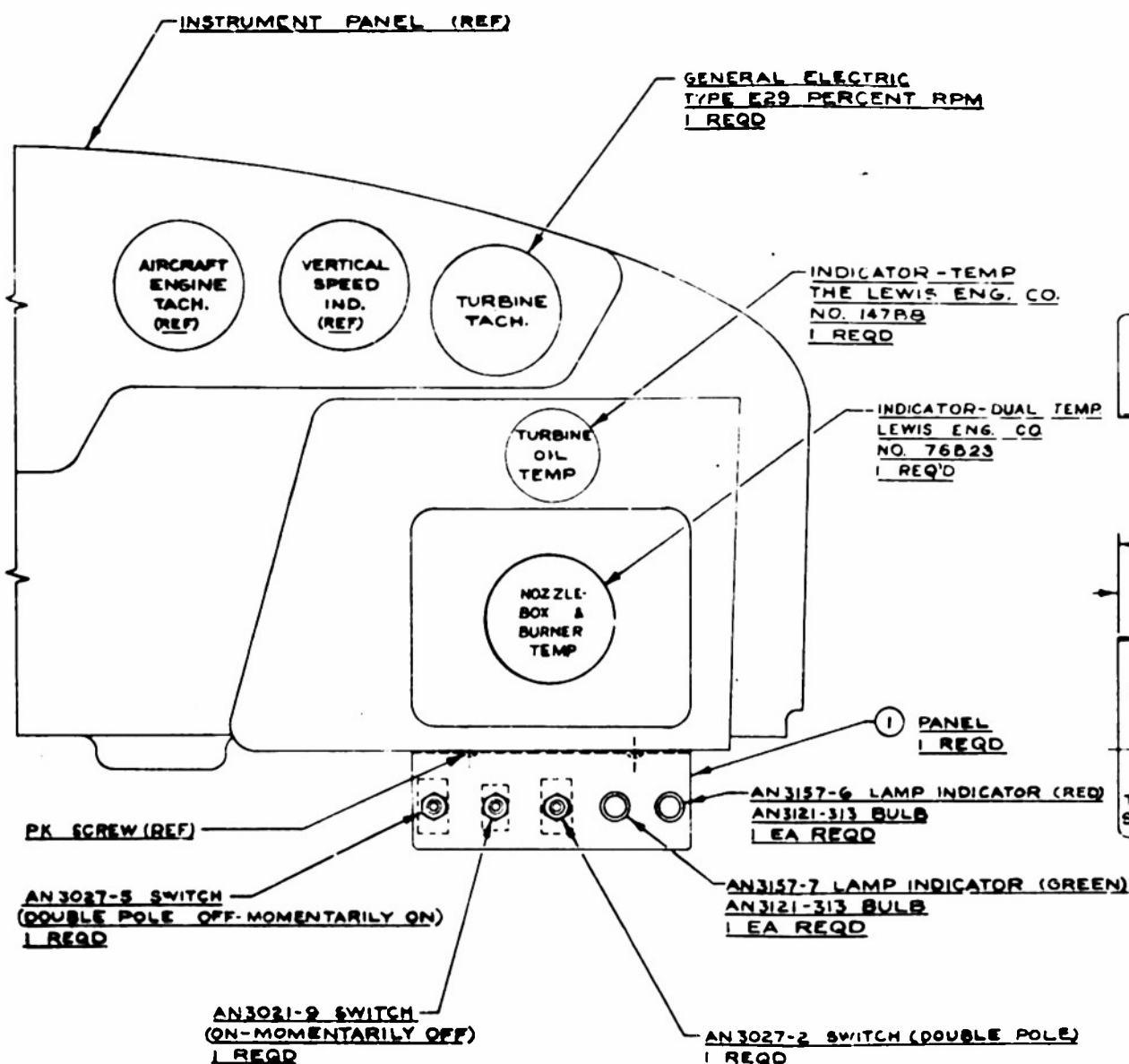
9

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8

7

12309-8 A



1 PANEL-CONTROL
.051-245-T3 AL SHT ALG
FULL SCALE

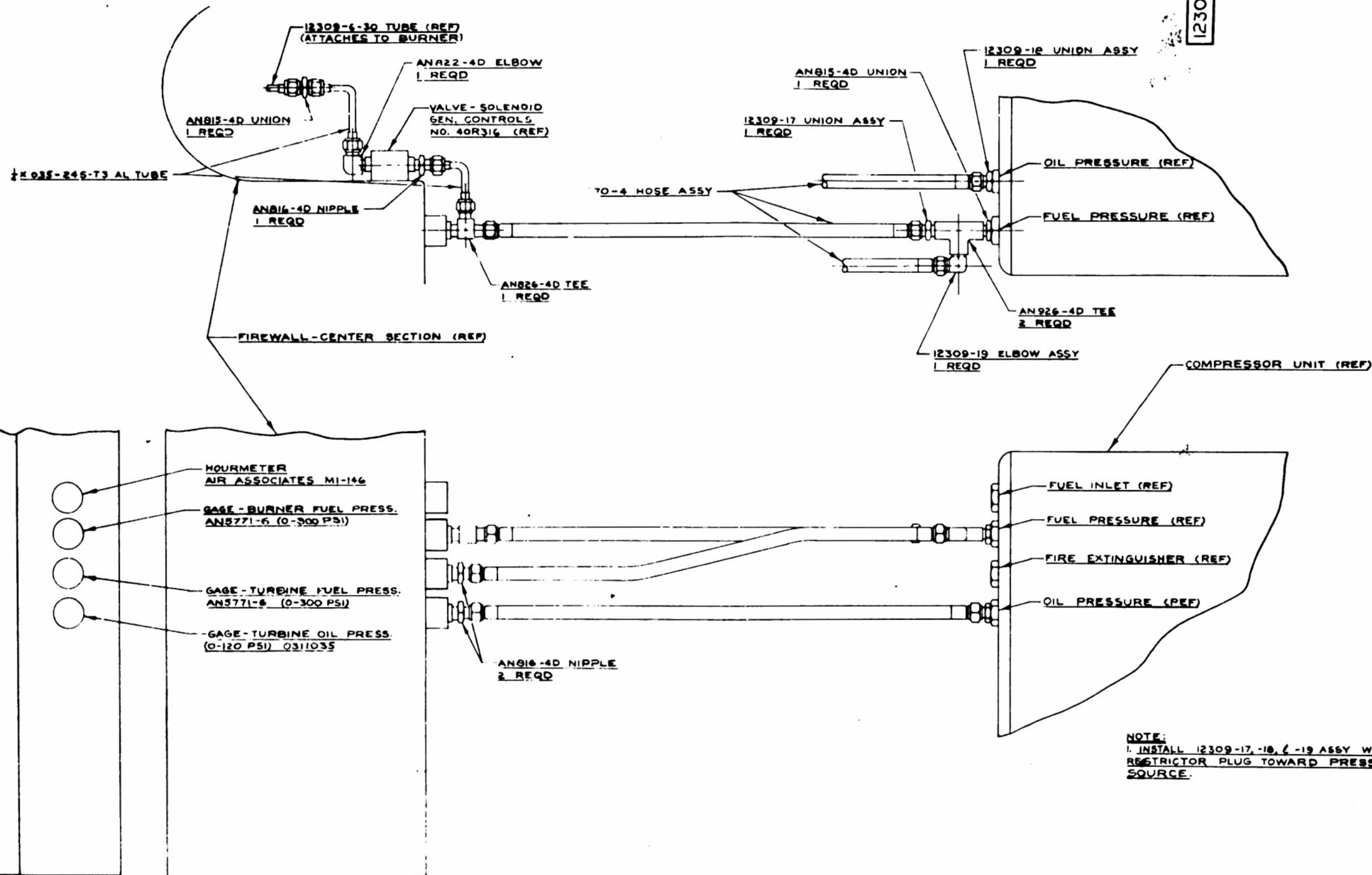
HALF SCALE

NOTE:
1. ALL PARTS IN -1 PANEL MAY BE SUBSTITUTED BY EQUIVALENT PARTS.
2. HOLES IN -1 PANEL ARE TO MATCH PART USED.
3. INSTALL GUARD OVER TURBINE START SWITCH.
4. REFER TO DWG NO. 12309-21 & AIRESEARCH DWG NO. 47003 FOR COMPLETE WIRING DIAGRAM.

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DO NOT SCALE FROM		UNLESS OTHERWISE NOTED DIMENSIONS SHOWN ARE ANGLES $\pm .1$ "		DEC. 1 AND FRACT. 1/16" .01" CIRCULAR RADIUS OR CIRCLES AND		HOLE FACES UP TO AND DEC. 1/16" DIA. AND FOR LARGER DIMENS		ALL SHARP EDGES		300	
DESIGNED BY	DATE	DESIGNED BY	DATE	NOTED	CONTROLS - TURBINE & BURNER		DATE		DWG NO.		12309-8 A
DESIGNED BY	DATE	DESIGNED BY	DATE	NOTED	CERENA AIRCRAFT CO.		DATE		DWG NO.		12309-8 A
DESIGNED BY	DATE	DESIGNED BY	DATE	NOTED	CERENA AIRCRAFT CO.		DATE		DWG NO.		12309-8 A

CONFIDENTIAL



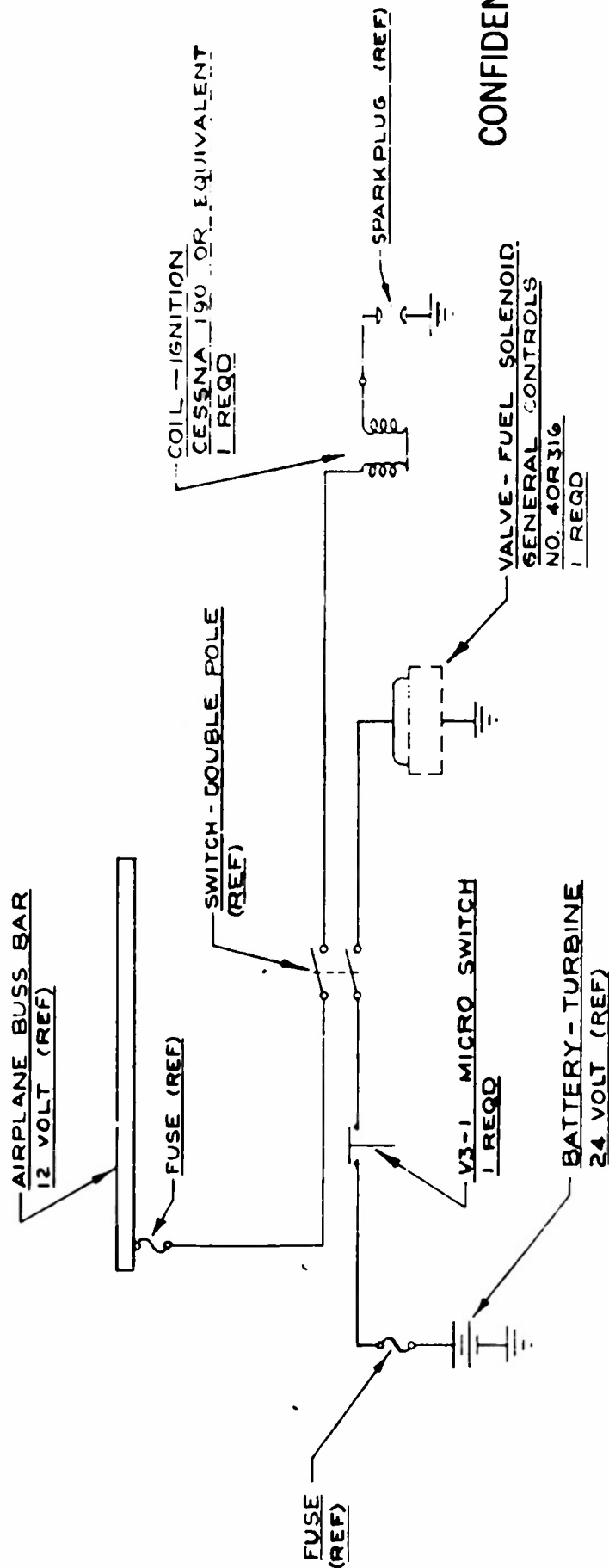
CONFIDENTIAL

DO NOT SCALE FROM		309	
UNLESS OTHERWISE NOTED DIMENSIONS ARE IN INCHES		309	
DIM. 1/16" FRACTION 1/16" IN. CORNER RADIUS OR CHAMFER AND		309	
SHOULDER 1/16" IN. AND 1/16" DIA. AND FOR LARGER DIMENSIONS		309	
ALL DIMENSIONS		309	
DESIGNED BY	DATE	DESIGNED BY	DATE
E.A. LAUER	8-1-51	E.A. LAUER	8-1-51
CHECKED BY	DATE	CHECKED BY	DATE
WEO	8-2-51	WEO	8-2-51
APPROVED TO SERIALS		APPROVED TO SERIALS	
SCHEMATIC - FUEL SYSTEM		SCHEMATIC - FUEL SYSTEM	
CESSNA AIRCRAFT CO.		CESSNA AIRCRAFT CO.	
WICHITA, KANSAS		WICHITA, KANSAS	
12309-20A		12309-20A	

CONFIDENTIAL

CONFIDENTIAL

12309-21



CONFIDENTIAL

DO NOT SCALE PRINT.		DIRECTIONS: OTHER WIRE NOTED DIMENSION LIMITS ARE: ANGLES .125" DEC. .015" FRACT. .001" .015" .031" CORNER RADIUS OR CHORDS AND SPOT FACED UP TO AND INCL. 1/4" DIA. .001" FOR LARGER. BESEAL ALL SHARP EDGES.		NO. 1		NO. 2		NO. 3		NO. 4		NO. 5		NO. 6		NO. 7		NO. 8		NO. 9		NO. 10		NO. 11		NO. 12		NO. 13		NO. 14		NO. 15		NO. 16		NO. 17		NO. 18		NO. 19		NO. 20		NO. 21		NO. 22		NO. 23		NO. 24		NO. 25		NO. 26		NO. 27		NO. 28		NO. 29		NO. 30		NO. 31		NO. 32		NO. 33		NO. 34		NO. 35		NO. 36		NO. 37		NO. 38		NO. 39		NO. 40		NO. 41		NO. 42		NO. 43		NO. 44		NO. 45		NO. 46		NO. 47		NO. 48		NO. 49		NO. 50		NO. 51		NO. 52		NO. 53		NO. 54		NO. 55		NO. 56		NO. 57		NO. 58		NO. 59		NO. 60		NO. 61		NO. 62		NO. 63		NO. 64		NO. 65		NO. 66		NO. 67		NO. 68		NO. 69		NO. 70		NO. 71		NO. 72		NO. 73		NO. 74		NO. 75		NO. 76		NO. 77		NO. 78		NO. 79		NO. 80		NO. 81		NO. 82		NO. 83		NO. 84		NO. 85		NO. 86		NO. 87		NO. 88		NO. 89		NO. 90		NO. 91		NO. 92		NO. 93		NO. 94		NO. 95		NO. 96		NO. 97		NO. 98		NO. 99		NO. 100		NO. 101		NO. 102		NO. 103		NO. 104		NO. 105		NO. 106		NO. 107		NO. 108		NO. 109		NO. 110		NO. 111		NO. 112		NO. 113		NO. 114		NO. 115		NO. 116		NO. 117		NO. 118		NO. 119		NO. 120		NO. 121		NO. 122		NO. 123		NO. 124		NO. 125		NO. 126		NO. 127		NO. 128		NO. 129		NO. 130		NO. 131		NO. 132		NO. 133		NO. 134		NO. 135		NO. 136		NO. 137		NO. 138		NO. 139		NO. 140		NO. 141		NO. 142		NO. 143		NO. 144		NO. 145		NO. 146		NO. 147		NO. 148		NO. 149		NO. 150		NO. 151		NO. 152		NO. 153		NO. 154		NO. 155		NO. 156		NO. 157		NO. 158		NO. 159		NO. 160		NO. 161		NO. 162		NO. 163		NO. 164		NO. 165		NO. 166		NO. 167		NO. 168		NO. 169		NO. 170		NO. 171		NO. 172		NO. 173		NO. 174		NO. 175		NO. 176		NO. 177		NO. 178		NO. 179		NO. 180		NO. 181		NO. 182		NO. 183		NO. 184		NO. 185		NO. 186		NO. 187		NO. 188		NO. 189		NO. 190		NO. 191		NO. 192		NO. 193		NO. 194		NO. 195		NO. 196		NO. 197		NO. 198		NO. 199		NO. 200		NO. 201		NO. 202		NO. 203		NO. 204		NO. 205		NO. 206		NO. 207		NO. 208		NO. 209		NO. 210		NO. 211		NO. 212		NO. 213		NO. 214		NO. 215		NO. 216		NO. 217		NO. 218		NO. 219		NO. 220		NO. 221		NO. 222		NO. 223		NO. 224		NO. 225		NO. 226		NO. 227		NO. 228		NO. 229		NO. 230		NO. 231		NO. 232		NO. 233		NO. 234		NO. 235		NO. 236		NO. 237		NO. 238		NO. 239		NO. 240		NO. 241		NO. 242		NO. 243		NO. 244		NO. 245		NO. 246		NO. 247		NO. 248		NO. 249		NO. 250		NO. 251		NO. 252		NO. 253		NO. 254		NO. 255		NO. 256		NO. 257		NO. 258		NO. 259		NO. 260		NO. 261		NO. 262		NO. 263		NO. 264		NO. 265		NO. 266		NO. 267		NO. 268		NO. 269		NO. 270		NO. 271		NO. 272		NO. 273		NO. 274		NO. 275		NO. 276		NO. 277		NO. 278		NO. 279		NO. 280		NO. 281		NO. 282		NO. 283		NO. 284		NO. 285		NO. 286		NO. 287		NO. 288		NO. 289		NO. 290		NO. 291		NO. 292		NO. 293		NO. 294		NO. 295		NO. 296		NO. 297		NO. 298		NO. 299		NO. 300		NO. 301		NO. 302		NO. 303		NO. 304		NO. 305		NO. 306		NO. 307		NO. 308		NO. 309		NO. 310		NO. 311		NO. 312		NO. 313		NO. 314		NO. 315		NO. 316		NO. 317		NO. 318		NO. 319		NO. 320		NO. 321		NO. 322		NO. 323		NO. 324		NO. 325		NO. 326		NO. 327		NO. 328		NO. 329		NO. 330		NO. 331		NO. 332		NO. 333		NO. 334		NO. 335		NO. 336		NO. 337		NO. 338		NO. 339		NO. 340		NO. 341		NO. 342		NO. 343		NO. 344		NO. 345		NO. 346		NO. 347		NO. 348		NO. 349		NO. 350		NO. 351		NO. 352		NO. 353		NO. 354		NO. 355		NO. 356		NO. 357		NO. 358		NO. 359		NO. 360		NO. 361		NO. 362		NO. 363		NO. 364		NO. 365		NO. 366		NO. 367		NO. 368		NO. 369		NO. 370		NO. 371		NO. 372		NO. 373		NO. 374		NO. 375		NO. 376		NO. 377		NO. 378		NO. 379		NO. 380		NO. 381		NO. 382		NO. 383		NO. 384		NO. 385		NO. 386		NO. 387		NO. 388		NO. 389		NO. 390		NO. 391		NO. 392		NO. 393		NO. 394		NO. 395		NO. 396		NO. 397		NO. 398		NO. 399		NO. 400		NO. 401		NO. 402		NO. 403		NO. 404		NO. 405		NO. 406		NO. 407		NO. 408		NO. 409		NO. 410		NO. 411		NO. 412		NO. 413		NO. 414		NO. 415		NO. 416		NO. 417		NO. 418		NO. 419		NO. 420		NO. 421		NO. 422		NO. 423		NO. 424		NO. 425		NO. 426		NO. 427		NO. 428		NO. 429		NO. 430		NO. 431		NO. 432		NO. 433		NO. 434		NO. 435		NO. 436		NO. 437		NO. 438		NO. 439		NO. 440		NO. 441		NO. 442		NO. 443		NO. 444		NO. 445		NO. 446		NO. 447		NO. 448		NO. 449		NO. 450		NO. 451		NO. 452		NO. 453		NO. 454		NO. 455		NO. 456		NO. 457		NO. 458		NO. 459		NO. 460		NO. 461		NO. 462		NO. 463		NO. 464		NO. 465		NO. 466		NO. 467		NO. 468		NO. 469		NO. 470		NO. 471		NO. 472		NO. 473		NO. 474		NO. 475		NO. 476		NO. 477		NO. 478		NO. 479		NO. 480		NO. 481		NO. 482		NO. 483		NO. 484		NO. 485		NO. 486		NO. 487		NO. 488		NO. 489		NO. 490		NO. 491		NO. 492		NO. 493		NO. 494		NO. 495		NO. 496		NO. 497		NO. 498		NO. 499		NO. 500		NO. 501		NO. 502		NO. 503		NO. 504		NO. 505		NO. 506		NO. 507		NO. 508		NO. 509		NO. 510		NO. 511		NO. 512		NO. 513		NO. 514		NO. 515		NO. 516		NO. 517		NO. 518		NO. 519		NO. 520		NO. 521		NO. 522		NO. 523		NO. 524		NO. 525		NO. 526		NO. 527		NO. 528		NO. 529		NO. 530		NO. 531		NO. 532		NO. 533		NO. 534		NO. 535		NO. 536		NO. 537		NO. 538		NO. 539		NO. 540		NO. 541		NO. 542		NO. 543		NO. 544		NO. 545		NO. 546		NO. 547		NO. 548		NO. 549		NO. 550		NO. 551		NO. 552		NO. 553		NO. 554		NO. 555		NO. 556		NO. 557		NO. 558		NO. 559		NO. 560		NO. 561		NO. 562		NO. 563		NO. 564		NO. 565		NO. 566		NO. 567		NO. 568		NO. 569		NO. 570		NO. 571		NO. 572		NO. 573		NO. 574		NO. 575		NO. 576		NO. 577		NO. 578		NO. 579		NO. 580		NO. 581		NO. 582		NO. 583		NO. 584		NO. 585		NO. 586		NO. 587		NO. 588		NO. 589		NO. 590		NO. 591		NO. 592		NO. 593		NO. 594		NO. 595		NO. 596		NO. 597		NO. 598		NO. 599		NO. 600		NO. 601		NO. 602		NO. 603		NO. 604		NO. 605		NO. 606		NO. 607		NO. 608		NO. 609		NO. 610		NO. 611		NO. 612		NO. 613		NO. 614		NO. 615		NO. 616		NO. 617		NO. 618		NO. 619		NO. 620		NO. 621		NO. 622		NO. 623		NO. 624		NO. 625		NO. 626		NO. 627		NO. 628		NO. 629		NO. 630		NO. 631		NO. 632		NO. 633		NO. 634		NO. 635		NO. 636		NO. 637		NO. 638		NO. 639		NO. 640		NO. 641		NO. 642		NO. 643		NO. 644		NO. 645		NO. 646		NO. 647		NO. 648		NO. 649		NO. 650		NO. 651		NO. 652		NO. 653		NO. 654		NO. 655		NO. 656		NO. 657		NO. 658		NO. 659		NO. 660		NO. 661		NO. 662		NO. 663		NO. 664		NO. 665		NO. 666		NO. 667		NO. 668		NO. 669		NO. 670		NO. 671		NO. 672		NO. 673		NO. 674		NO. 675		NO. 676		NO. 677		NO. 678		NO. 679		NO. 680		NO. 681		NO. 682		NO. 683		NO. 684		NO. 685		NO. 686		NO. 687		NO. 688		NO. 689		NO. 690		NO. 691		NO. 692		NO. 693		NO. 694		NO. 695		NO. 696		NO. 697		NO. 698		NO. 699		NO. 700		NO. 701		NO. 702		NO. 703		NO. 704		NO. 705		NO. 706		NO. 707		NO. 708		NO. 709		NO. 710		NO. 711		NO. 712		NO. 713		NO. 714		NO. 715		NO. 716		NO. 717		NO. 718		NO. 719		NO. 720		NO. 721		NO. 722		NO. 723		NO. 724		NO. 725		NO. 726		NO. 727		NO. 728		NO. 729		NO. 730		NO. 731		NO. 732		NO. 733		NO. 734		NO. 735		NO. 736		NO. 737		NO. 738		NO. 739		NO. 740		NO. 741		NO. 742		NO. 743		NO. 744		NO. 745		NO. 746		NO. 747		NO. 748		NO. 749		NO. 750		NO. 751		NO. 752		NO. 753		NO. 754		NO. 755		NO. 756		NO. 757		NO. 758		NO. 759		NO. 760		NO. 761		NO. 762		NO. 763		NO. 764		NO. 765		NO. 766		NO. 767		NO. 768		NO. 769		NO. 770		NO. 771		NO. 772		NO. 773		NO. 774		NO. 775		NO. 776		NO. 777		NO. 778		NO. 779		NO. 780		NO. 781		NO. 782		NO. 783		NO. 784		NO. 785		NO. 786		NO. 787		NO. 788		NO. 789		NO. 790		NO. 791		NO. 792		NO. 793		NO. 794		NO. 795		NO. 796		NO. 797		NO. 798		NO. 799		NO. 800		NO. 801		NO. 802		NO. 803		NO. 804		NO. 805		NO. 806		NO. 807		NO. 808		NO. 809		NO. 810		NO. 811		NO. 812		NO. 813		NO. 814		NO. 815		NO. 816		NO. 817		NO. 818		NO. 819		NO. 820		NO. 821		NO. 822		NO. 823		NO. 824		NO. 825		NO. 826		NO. 827		NO. 828		NO. 829		NO. 830		NO. 831		NO. 832		NO. 833		NO. 834		NO. 835		NO. 836		NO. 837		NO. 838		NO. 839		NO. 840		NO. 841		NO. 842		NO. 843		NO. 844		NO. 845		NO. 846		NO. 847		NO. 848		NO. 849		NO. 850		NO. 851		NO. 852	
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